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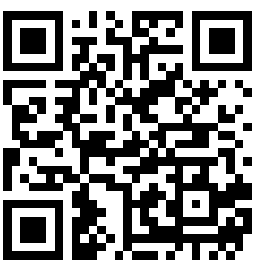

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WATER FOR PEACE

A Report of
Background Considerations
and Recommendations
on the Water for Peace Program

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WATER FOR PEACE

A Report of Background Considerations and Recommendations

of the

Water for Peace Program

THE INTERDEPARTMENTAL COMMITTEE ON WATER FOR PEACE

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UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

MEMORANDUM

To: The Secretary of the Interior
The Secretary of State

From: Chairman, Interdepartmental Committee on Water for Peace

Subject: Report of the Committee

President Johnson launched the Water for Peace program in his address of October 7, 1965, in which he pledged United States participation in a "massive cooperative international effort to find solutions for man's water problems." Steps already have been taken to increase U.S. support for water projects within the foreign assistance program. The enclosed report prepared by an Interdepartmental Committee on Water for Peace representing interested agencies of the Federal Government briefly surveys the world's water problems and considers further actions which can be taken to advance this international cooperative effort.

Water is vital to human life and to man's pursuit of happiness. It is essential to man's health, yet almost a billion people in the world lack even the simplest dependable supplies of potable water for personal and domestic use. Most of them suffer or have recently suffered from debilitating diseases that are water borne or that are attributable to a lack of water for personal hygiene; each year an estimated 500 million people are afflicted by such illnesses, and ten million people - about half of them infants - die. Millions suffer undernourishment and starvation because water supplies are not properly used or developed for food production. Water contributes in important ways to commerce and industrial development. Water also is an integral part of the human environment.

All nations have water problems, but they differ in kind and character depending upon the nature and extent of their water resources, the state of technological and industrial development, population density, historical experience, and cultural values. In the industrialized countries these problems revolve around water management, water pollution, and water reuse to serve highly intricate and intensive demands. In the less developed countries the lack of information, skilled manpower, cultural, legal and government institutions, and adequate

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planning represent the areas of most immediate need. International river systems in all regions of the world present significant opportunities to the riparian countries for mutual advantage and peaceful cooperation through coordinated development programs.

For these reasons, an international cooperative effort to advance water development throughout the world is aptly named the Water for Peace Program because the water cycle pays no attention to the boundaries men draw on maps; because hunger, disease and misery are everywhere the enemies of mankind; because no one nation has a monopoly of knowledge and talent; and because by working together toward the solution of their common problems, men advance a little down the road to universal peace.

Chapter II of the enclosed report summarizes the ways in which water can fulfill human needs and promote a better life. Chapter III reviews the programs required to develop water resources to serve these purposes, particularly from the point of view of national and local entities responsible for water development programs. Chapter IV describes the opportunities available to develop international river systems. Chapter V briefly reviews the many interrelated bilateral and multilateral programs and organizations operating to improve water development. Chapter VI discusses several suggested organizational arrangements that should be undertaken to improve mutual cooperation in water development within the United Nations family, at the regional and subregional level, and within the United States to support the worldwide effort.

Chapter VII sets forth a number of specific recommendations which the Interdepartmental Committee on Water for Peace believes are worthy of consideration to stimulate the rate of progress in water development throughout the world and to promote a more systematic framework in which the efforts of individual countries and international organizations can be coordinated to fulfill this end.

This preliminary review of the world's water problems has led the Committee to four basic conclusions: First, that notwithstanding the many significant current international water programs, the worldwide effort is not keeping pace with the worldwide needs. Second, water problems are so varied and the opportunities for development so complex, that water resources development in each country should be fully coordinated with the development of other economic and human resources. Third, that the most urgent need throughout the developing world is for an increased understanding of and capacity to deal with the problems involved in water resources development and management. Fourth, that

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existing and anticipated technological advances make possible the solutions of problems which earlier were considered insurmountable.

Within the framework of these conclusions the recommendations include a number of specific proposals to provide more data and information about water problems, resources, and opportunities for development; more trained manpower to put knowledge and technology to work; improved planning and organization of water programs at local, national and regional levels; and enhanced utilization of science and technology for water development. The recommendations also implement the Committee's belief that many of the cooperative efforts of the world community to assist in these programs can best be coordinated by, and channeled through, strengthened or newly established multilateral institutions and programs at the regional and subregional levels.

No specific recommendations are included with respect to international financing of construction projects other than that this subject be further studied and kept under constant surveillance. One reason for this is that the immediate need is not for new capital financing but for more well-planned projects which can meet the lending requirements of the many existing sources of financial assistance. Second, internal sources of financing must be more thoroughly surveyed since these sources must provide the greatest percentage of capital requirements. A third consideration is that many of the countries in greatest need of new water facilities lack the technical and institutional capacity to operate and maintain them after construction.

Inasmuch as this report has been prepared by a group within the United States Government, these recommendations are focussed on what the United States might do both through its own programs and through its representation and voice in international councils in urging other nations to make parallel and cooperative contributions. This should not obscure recognition of the basic premise that nations and regions of the world which have water problems and desire to respond to them by promoting water development, must undertake this responsibility themselves. Through the Water for Peace Program the world community can exchange knowledge and experience, offer encouragement, supply technology, and provide technical and financial assistance, but one nation or region cannot do the job for any other. This principle of self-help is fundamental to the program.

In addition it is hoped that this report, which was produced primarily for the purpose of orienting the thinking in U.S. government agencies

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toward making a more effective contribution to solving the world's water problems, will be useful to participants at the International Conference on Water for Peace. It seems probable that it contains material which should be helpful in discussions, and should stimulate action along constructive lines.

Kenneth Holum
Assistant Secretary of the Interior

Enclosure

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I. INTRODUCTION

Water is to man the most important single substance, with the exception of the air he breathes. Counting the polar ice caps, it covers no less than three-fourths of the earth's surface. In addition to the vast quantities in the oceans and polar ice caps, there are an estimated 3.6 trillion acre-feet of fresh and saline water present in inland lakes and seas, rivers and streams, and in the ground to a depth of one-half mile. Each year some 80 billion acre-feet in the form of rain and snow fall on the land, of which 27 billion acre-feet a year are returned to the sea by rivers, glaciers, and groundwater seepage. The remaining 53 billion acre-feet return to the atmosphere or replenish ground and surface storage. Most of this huge supply of water is little used by man.

In absolute terms, an enormous amount of water is available for man's use. But so capricious has Nature been in her distribution of it, and so inept has man been in making use of it, that water, or its lack, has always been one of the greatest problems confronting the human race. It is one of the bitter ironies of the human story that water, the very symbol of life itself, should be so closely and continuously associated with suffering and death. From time out of mind, water has been the focus of conflict among individuals, families, tribes, and nations. Flood and drought alternately have killed uncounted millions, while legions more have died from waterborne diseases. Other millions have suffered more slowly as wind and rain stripped their lands of precious topsoil. In parts of the world people are jammed together in stifling numbers while vast areas remain empty because too little or too much water appears to render them uninhabitable.

It seems a paradox that water should still be one of humanity's most critical problems. Yet it is precisely that and the problem is becoming more vexatious with every passing year. There is an urgent requirement for water that is clean and pure enough for human use—water for drinking; water for cooking; water for washing and bathing. Beyond that, water for food production; water for industry; water for commerce, transportation, and electric power generation. Water, even for such purposes as pleasure and recreation.

Water management is not a problem that is confined to the developing countries of the world. In the more advanced nations competition for the use of water supplies is growing and the supply of usable water is becoming scarce. The processes of industrialization and urbanization befoul the rivers and threaten man's ecological balance with nature. Stories of floods, and drought, and pollution appear with increasing frequency in the daily press.

Three billion human beings inhabit the earth today, and every day there are 200,000 more persons on this planet. By the year 2000, which is a bit more than 33 years away, these 3 billion people will have grown to 6 billion at the present rate of increase. But the water needs of the additional 3 billion will not be satisfied by simply doubling the water used today; it must expand several times over if aspirations for economic and social development are to be realized.

To excuse his own woefully inadequate performance in the provision of water, man could, until recently, plead ignorance and incapacity. But this plea becomes progressively harder to sustain in the face of the advances in every field of human endeavor.

President Johnson launched the Water for Peace Program in October 1965 in an address to the delegates to the First International Symposium on Water Desalination in Washington, D.C. The President noted that the need for water is worldwide and so is the responsibility for promoting its beneficial use and full development. Accordingly, he pledged the participation of the United States in "a massive cooperative international effort to find solutions for man's water problems."

This is the concept of the Water for Peace Program. It is global in scope because the water cycle pays no attention to the boundaries men draw on maps; because hunger, disease and misery are everywhere the enemies of mankind; because no one nation has a monopoly of knowledge and talent; and because by working together toward the solution of their common problems, men advance a little down the road to universal peace.

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The Water for Peace Program must build upon the many solid achievements in resources development that have already been recorded by nations working by themselves, with help from others through mutual arrangements, and through the United Nations Organization and the specialized agencies. It is essential that nothing so far gained be lost, that no promising program be bypassed or ignored, and that maximum use be made of the vast experience, knowledge, and institutional relationships that have been patiently developed over many years.

The Water for Peace Program also must recognize that water's contribution to the elimination of disease, and hunger, and poverty can be but marginal in the absence of correlative measures aimed at the same objectives. Pure water alone will not keep people from getting sick. They must also adopt good health practices, correct bad sanitation, control the breeding of flies and mosquitoes, and obtain well-balanced diets. Water for irrigation will be largely ineffective in the absence of fertilizer, pesticides, good seed and efficient cultivation techniques. Water for industrial processes is useless if other resources are lacking. The benefits from water progress can be quickly submerged under uncontrolled increases in population. Lastly, water development today is of little value unless it is founded on an institutional base that will permit it to serve tomorrow's needs as well.

This report was prepared by the Interdepartmental Committee on Water for Peace, established by Secretary of State Dean Rusk and Secretary of the Interior Stewart L. Udall and composed of representatives from a number of departments and agencies of the U.S. Government having an interest in water programs. The report is in the nature of a general and preliminary survey of the matters which must be dealt with in the long struggle to meet humanity's increasing needs for water. As such, it raises more questions than it answers and poses more problems than solutions. It does, however, call attention to the gaps to be filled and the deficiencies to be overcome in order that the great struggle can be won.

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II. HUMAN NEEDS AND OPPORTUNITIES

A. Water for Living

The Importance of Reliable Water Supply to Health

The well-being of communities, both urban and rural, is highly dependent on the water available for their daily needs. Water is needed for human consumption; water is needed for personal, household and community cleanliness; water is needed by industry as a raw material and a coolant, and it is needed for stock watering in the rural communities. Without adequate supplies of safe water, all of these activities are curtailed, and as a consequence overall economic and social development is inhibited.

All of the above are important, but water for human consumption and sanitation are of greater social and economic importance because the effect on the health of the population in turn influences all other activities. Disease not only causes high death rates and short life expectancy, but what is probably more important, it is debilitating and saps the much-needed energy of the population.

Although all nations have deficiencies in providing adequate supplies of potable water for domestic use, the problem is most critical among the developing countries. Of the one and a half billion people who live in the developing portions of the free world, it is conservatively estimated that nearly a billion obtain their water from unsanitary sources. As a result, most of them are suffering or have suffered for extended periods in the immediate past from waterborne or water-associated diseases; each year an estimated 500 million people are affected by such incapacitating illnesses, and as many as 10 million people—about half of them infants—die.

Dysentery, typhoid fever, cholera, and a variety of lesser enteric diseases are often the direct consequence of drinking polluted water, or when not, their cause can usually be traced to insanitation due to a lack of water. Other diseases, such as typhus, trachoma, and yaws also attack those who are unable to obtain enough water to keep themselves, their clothing and their dwellings to a minimum standard of cleanliness. It is estimated that as many as half a billion people suffer from trachoma, an eye disease often causing loss of vision, whose cause is directly attributable to the lack of the simplest requirements for personal hygiene.

There are numerous examples to demonstrate the extent to which waterborne diseases may be reduced by supplying safe piped water. In Japan a survey of rural areas revealed that the installation of a safe water supply reduced the number of cases of intestinal disease by over 70 percent and that trachoma was reduced by 64 percent. After water works sanitation was introduced in Uttar Pradesh, India, cholera death rates were reduced by 74.1 percent and the typhoid fever death rates by 63.6 percent. The United States is a prime example of how, through the development of the water works industry, there have been phenomenal reductions in waterborne and water-related diseases. The last case of cholera in the United States occurred many years ago, and typhoid fever is rare. Trachoma is almost unheard of in the United States, and it appears now only in relatively small groups of American Indians in areas with major water supply problems.

The cost of these illnesses cannot be estimated with any degree of accuracy, but it is without question of substantial consequence. The total cost includes the direct cost of treatment in the form of drugs, hospital facilities, and medical staff; the cost of lost time and inefficiency of sick workers; and the personal tragedy of needless illness and death.

When health is considered in a broad sense as the physical and mental well-being of man, the arduous labor of obtaining water must be considered. In many parts of the world women and children spend as much as 50 percent of their time hauling water for household and stock watering purposes.

It seems surprising but it nonetheless is tragically true that the importance of adequate water supply to life and health, as well as to economic development, is still not fully recognized by many governments, let alone by the people, where its lack is one of the greatest obstacles to human and economic progress. Water supply facilities are often bypassed in favor of projects

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to provide transportation, power, and industry. Popular attitudes, shaped by centuries of experience, often accept muddy and contaminated water as an inevitable aspect of the environment. For these reasons, an important immediate requirement for accelerated water progress is to expand the worldwide awareness of the significance of clean water for serving human needs and to encourage a determination at all levels to move ahead with practical programs to close the water gap.

The Dimensions of the Water Supply Problem

Data in regard to community water supplies in the developing countries is very limited and in many cases of questionable validity. The following discussion is based on that data which is available and should be considered more as a general survey of the situation rather than an accurate presentation of facts. Probably one of the greatest needs today in the developing countries is for accurate information on which to base plans for future activities. Before any large-scale program in community water supply is launched, information should be obtained about the number of water supplies existing today, the type of service provided, the quality of the water provided, the ability of the population to afford water services of various types, the manpower available to carry out water supply activities, and institutions which can be depended on to manage and maintain water supply facilities after they are installed.

Table 1 sets forth a summary of the available water service in the developing nations of the free world, as it was thought to exist in 1964. Inasmuch as accurate data does not exist, the estimates shown are probably correct only as they relate to orders of magnitude. Furthermore, these figures make no attempt to evaluate the water supplies in regard to quantity or quality of the water or the reliability of the service. In fact, many of these facilities are far from adequate, and substantial renovation and extension will have to be undertaken before they can provide minimal health requirements.

Of the 1.1 billion people living in rural areas, nearly 800 million had no water service at all in 1964. Less than 300 million were served by public outlets and very few enjoyed water service from house connections. Forty percent of the urban population, comprising around 140 million people, had no water service, and an additional 90 million obtained water from public outlets. All told, more than 900 million people were without any kind of public water service, and another 365 million relied on public outlets. Only about 170 million, or 1 person out of 9, had water piped to his habitation.

This was in 1964. The population has continued its expansion, so that by 1974, it is estimated that at least another 350 million persons will have been added. Of this number the urban portion is increasing twice as rapidly as the rural segment. Service in the form of house connections or public outlets will be required for an additional 140 million just to maintain the same levels of service existing in 1964. Thus, it is apparent that considerable effort will be required simply to maintain the status quo, inadequate though it may be, much less to meet the increasing demand for water within the developing areas of the world.

Urban Water Supply

There is such a wide variation throughout the world in the quantity and quality of existing water supplies, the human and economic needs, and the extent of the resources which can be brought to bear, that water supply problems and their solution can be discussed herein only in terms of the broadest generalizations. Detailed studies and difficult decisions are required in each particular case. For purposes of even a general discussion, however, it is useful to make a distinction between urban and rural water supply problems. No single dividing line is attempted to be drawn in this report or in the literature between the two kinds of situations. In some countries for census or other administrative purposes the urban classification may begin with communities as small as 2,000 population or as large as 25,000. For a rule of thumb, however, an urban area may be thought of as a population concentration of more than 5,000 people.

The density of population in urban areas creates many complicating problems. Per capita consumption is higher, for not only is more water typically used for domestic purposes, but water also must be supplied for industrial and public purposes. Waste of water is more difficult to control. The greater variation between periods of low and peak demand requires extra capacity and presents more difficult problems of system operation. The constant threat of pollution is magnified, and ideally, the provision of facilities for disposal of sewage and other pollutants, as well as surface runoff, should go hand in hand with provision of facilities for water supply.

Notwithstanding these complicating factors, there are a number of offsetting considerations which in many cases dictate the selection of urban areas for earliest focus of government attention. Availability of technical personnel and the chances of forming an

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organization which can effectively administer the waterworks are usually much more favorable in the urban than in the rural environment. Urban populations are generally increasing more rapidly than rural populations, and the urgency of the need may create a greater willingness to act. Mechanisms of communication, such as through schools and newspapers, may be more readily at hand to educate the public in the value and use of water. The per capita benefit that can be realized from an input of engineering skills, where trained engineers are in short supply, may be greater in connection with the design, construction, and operation of urban systems with the installation of rural facilities. Local financial support may be more readily attainable in urban areas. Lastly, urban communities are generally regarded as pacesetters in cultural innovation, and it may be difficult or impossible to convince rural inhabitants of the need for better standards of water service and new institutional arrangements if their urban brethren have not accepted them first. It is because of these many factors that the World Bank, for example, has found few instances where rural water projects could meet its criteria for investment.

The guiding principle for the design, construction, and operation of new or improved public water supply systems is to provide—by the simplest means—for the most people—at the lowest reasonable cost—an adequate amount—of safe water—under pressure at convenient outlets—24 hours a day, 7 days a week, 52 weeks a year.

The requirements for any given area will be influenced by the criteria used in deciding the extent of the need and the objectives to be attained in planning the stages of development. They will most certainly differ according to the customs and the living habits of the people involved, the quality and quantity of the water source, the material, financial, and human resources that can be allocated to the work, and the time involved in collecting information, developing plans, and completing the institutional arrangements necessary to enable the system to function.

One of the important judgments that has to be made in planning urban systems at each stage of development is the accessibility of the water service to be provided. The ultimate desired objective, of course, is to supply water within each house to several appropriate types of fixtures, for kitchens, lavatories, water closets, and laundry. As indicated by the figures in table 1, however, this objective is beyond the reach of many communities in many countries.

A second factor that must be considered in the design of urban systems is whether facilities should be installed to meter the flow in order to restrict consumption, reduce waste, and permit collection of charges from consumers based on volume of household use. Comparative studies show that per capita consumption of water may be two to four times smaller in communities in which water supply is metered and prices charged on the basis of quantity consumed, than in comparable communities where these limitations do not prevail. On the other hand the cost of installing meters, reading them, servicing them and billing customers is considerable and may be found to be an uneconomic allocation of available resources during intermediate periods.

Additional important considerations are the necessity of treatment facilities to attain desirable levels of purity and the installation of sewerage disposal systems. The first is usually an absolute necessity in order to assure the purity of the water supply. The design of treatment works must be considered, however, in relation to the quality of alternative sources of supply and alternative measures for protecting the potability of the sources whether they be from surface water or ground water. The design of sewerage systems must take into consideration the effect of existing disposal measures in relation to the cost of water treatment both for the community served and the other communities downstream that might also rely on the same water source. The experience in the United States has been that urban concentration requires that both water supply and sewage disposal be considered in the planning, operation, and financing of community water systems. Many of the projects assisted from international funding sources include both aspects of the urban water supply picture. In many cities in the developing world, however, the choice may have to be made to defer improvement of disposal facilities until a later date.

All of the foregoing considerations bear on the difficult decision that has to be made regarding the estimated per capita consumption of the water supplied. Present rates of consumption vary all the way from the few quarts a day purchased from a street vendor to as much as 250 gallons per day. It is interesting to note that the engineers of classical Rome constructed 359 miles of aqueduct to provide 50 gallons per day to each citizen, whereas 17th-century Paris provided only 2½ quarts.

The average daily per capita use in American cities is about 150 gallons. While the pattern of this use varies considerably from city to city, this total may be

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TABLE 1.—*Estimated availability of water service in 1964*

	Middle America		South America		North Africa		South Africa		West Asia		East Asia		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1964 total population [1]	63.5	100.0	158.4	100.0	58.5	100.0	234.5	100.0	77.2	100.0	857.7	100.0	1,467.8	100.0
Urban population	28.3	44.5	80.5	50.8	19.1	32.7	27.4	11.7	25.5	33.0	161.1	18.4	341.9	23.3
Urban population served:														
House connections	15.6	55.0	49.9	62.0	10.9	57.0	3.6	13.0	9.9	39.0	24.2	15.0	114.1	33.4
Public outlets	8.5	30.0	20.9	26.0	3.8	20.0	10.4	38.0	9.2	36.0	37.1	23.0	89.9	26.3
Urban population not served	4.2	15.0	9.7	12.0	4.4	23.0	13.4	49.0	6.4	25.0	99.8	62.0	137.9	40.3
Rural population	35.2	55.5	77.9	30.0	49.2	67.3	207.1	88.3	51.7	67.0	714.6	81.6	1,125.9	76.7
Rural population served:														
House connections	10.6	20.0	23.4	30.0	3.9	10.0	4.1	2.0	1.0	2.0	14.3	2.0	57.3	5.1
Public outlets	7.0	20.0	15.6	20.0	7.9	20.0	51.8	25.0	12.9	25.0	178.7	25.0	273.9	24.3
Rural population not served	17.6	50.0	38.9	50.0	27.6	70.0	151.2	73.0	37.8	73.0	521.6	73.0	794.7	70.6
	Estimated 1974 population													
1974 total population	80.9	100.0	203.2	100.0	73.7	100.0	289.3	100.0	97.3	100.0	1,087.6	100.0	1,832.0	100.0
Total urban population	38.0	47.0	108.2	53.2	25.7	34.9	36.8	12.7	34.3	35.3	216.5	19.9	459.5	25.1
Total rural population	42.9	53.0	95.0	46.8	48.0	65.1	252.5	87.3	63.0	64.7	871.1	80.1	1,372.5	74.9
	Additional water supply requirements needed by 1974 to maintain 1964 levels of service													
10-year population increase	17.4	.....	44.8	.....	15.2	.....	54.8	.....	20.1	.....	211.9	.....	364.2	.....
10-year urban increase	9.7	100.0	27.7	100.0	6.6	100.0	9.4	100.0	8.8	100.0	55.4	100.0	117.6	.....
Additional urban service:														
House connections	5.3	55.0	17.2	62.0	3.7	57.0	1.2	13.0	3.5	39.0	8.3	15.0	39.2	.....
Public outlets	2.9	30.0	7.2	26.0	1.3	20.0	3.6	38.0	3.1	36.0	12.7	23.0	30.8	.....
Urban population not served	1.5	15.0	3.3	12.0	1.6	23.0	4.6	49.0	2.2	25.0	34.4	62.0	47.6	.....

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10-year rural increase	7.7	100.0	17.1	100.0	8.6	100.0	45.4	100.0	11.3	100.0	156.5	100.0	246.6	.....
Additional rural service:														
House connections	2.3	30.0	5.1	30.0	0.9	10.0	1.0	2.0	0.3	2.0	3.1	2.0	12.7	.....
Public outlets	1.6	20.0	3.4	20.0	1.7	20.0	12.3	25.0	2.7	25.0	39.0	25.0	60.7	.....
Rural population not served	3.8	50.0	8.6	50.0	6.0	70.0	32.1	73.0	8.3	73.0	114.4	73.0	173.2	.....

[1] All population number figures are in millions and are from Department of Commerce data.

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broken down into an average of 70 gallons for commerce and industry, 10 gallons for public use, and 70 gallons for household uses (it take 3 to 6 gallons to flush a toilet, 30 to 40 gallons for a tub bath, 20 to 30 gallons to run a washing machine). As much as 20 percent of the total may be wasted.

At the other end of the water-service spectrum is the household which obtains water from a public tap located along the street some distance from the home. Experience has shown that under these conditions the consumption of water will vary between 4 and 10 gallons per capita per day depending on the distance the water must be carried. This amount of water is not fully adequate for health, as it is not sufficient to maintain suitable personal or household cleanliness, and, of course, does not provide water for sewerage. The water actually needed for good health protection is somewhere between these figures, probably 25 to 30 gallons per capita per day for domestic use. This amount of water is adequate to provide for daily baths, waterborne sewage, suitable washing of dishes and utensils, and for maintaining cleanliness of the home itself.

The installation of systems to supply a daily domestic consumption of around 30 gallons per capita is beyond the reach of many urban communities in the next several decades, as it will require a substantial amount of economic development and increased personal income before most families in these communities will be able to afford plumbing inside their homes or be able to pay for this quantity of water. In the interim, systems will have to provide for customers in a variety of categories. Many will be required to obtain their water from the public taps or from a single tap on their premises.

Rural Water Supply

In spite of the continued worldwide trend toward urbanization, approximately 75 percent of the world's population still lives in rural communities. Residence patterns range from nomadic tribes and long-established hamlets of several dozen people, to rapidly growing suburban communities. There is a tremendous variation in the availability, quality, and use of water, and in the cultural practices relating to this resource that is so vital to human life and happiness.

Reliable data regarding water service is notable by its absence. The rough estimates summarized in table 1 indicate that nearly 800 million rural inhabitants in the developing countries are wholly without water service to meet their basic needs, and only a relative handful of the remainder have piped water available in their homes. It should be remembered, also, that even in the most advanced nations, there still remain many rural pockets where water service is far from adequate. In total human terms, the rural areas of the world constitute the sector of greatest need.

In a majority of rural situations, existing methods for obtaining water are extremely primitive. In most cases water is dipped from mudholes, ponds, canals, streams, and other surface sources, although in some civilizations water is obtained from wells and from underground aqueducts, called a ghanat or kharez, laboriously excavated by hand to carry ground water from distant hills. Under these circumstances, substantial benefits can often be provided by simple improvements. A spring can be tapped with a pipe carrying clean, clear water to an accessible location. A well can be covered to reduce pollution from human use, and surface ponds can be fenced to prevent pollution by animal wastes. A primitive sand filter can be established. Relatively simple wells can be dug and pumps installed to replace unsanitary shallow wells or other superficial sources. Initiation of basic sanitation measures may sharply reduce waterborne disease.

The fact that rural communities usually are based on closely interwoven agricultural economies has an important bearing on supply and sanitation relationships. Frequently water sources serve both human and agricultural purposes, and this fact needs to be taken into consideration in the design of improved systems. Attention also must be given to the management of both human and animal wastes to eliminate pollution of the water source.

Because of the relative simplicity of supply and sanitation measures that will yield marked improvement in the initial stages of rural development, there are potential opportunities for using indigenous labor and local materials to fill many of these needs. Also, first priority must be given to development of sources of supply per se without distribution systems.

While financing, particularly from local sources, is always an important problem for rural water progress, the more critical needs are for education of the rural residents, particularly community leaders, in the importance of clean water and in proper personal and public health practices; for creation of local institutions to support and maintain water systems; and for provision of technical assistance in the design, installation, operation, and use of water facilities. Furthermore, in view of the massive need in rural areas, no program aimed at upgrading rural water service can begin to succeed without strong support from the national government. This in turn requires close cooperation

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among the ministries responsible for public health, agriculture, and education, as well as those concerned with public works and other aspects of water resources development.

Paying for Water Service

In view of the massive need for radical improvement in water service throughout the world to meet even minimum health standards, much less the requirements for personal convenience and economic development, the hard question arises as to where the money is to come from to finance the costs of installation, operation, and maintenance of the necessary facilities. There is only one possible answer to this question—in the long run, most of the money must come from the consumers of the water supplied. Almost all of the international financial assistance available now or in the foreseeable future is on a loan basis, repayment for which must be assured. Tax-generated public funds are generally so limited in relation to national needs, particularly in the developing countries, that the bulk of public investment in nonreimbursable programs must be assigned to those sectors in which, unlike water service, the insistence on beneficiary payments is impractical or self-defeating.

The provision of dependable water supplies is a service which is well adapted to charging the consumer on a basis proportional to his individual benefit. The technology and the institutional arrangements for doing this are well known and readily available. The experience of the developed countries demonstrates that once the principle of user payment is accepted and organizational arrangements established to assure collection, private capital will be attracted to investment in water supply facilities, particularly through purchase of revenue bonds of municipal systems.

The key to substantial progress in water supply programs, therefore, is the principle that waterworks be self-supporting; that they be operated as public utilities in the same fashion as power and telephone companies; and that payments by consumers should cover the costs of source development, treatment, distribution, operation, maintenance, and administration. The notion that water should be "free" to the consumer must be abandoned.

Recognition of the essential principle that consumers must pay for the costs of water supply runs head on into the inescapable fact that most of the 900 million people in the developing world who obtain their meager water supplies from unsanitary sources simply are too poor to pay for a water service that is adequate by any modern standards. Finding a way out of this dilemma is probably the greatest challenge to the water supply planner.

The solution must undoubtedly come from varying combinations of a number of factors depending on the circumstances of each situation. One is to recognize that even the very poor can afford to pay something, if only a token payment of a few pennies a day. Such payments are being made today where water is purchased from private vendors; it has been estimated, for example, that water purchased in Delhi, India, costs an average of the equivalent of 1 U.S. cent per gallon, whereas nearly a hundred gallons can be purchased for the same price from the public piped system.

Determined efforts should be made to reduce the costs of water service to poverty-ridden communities, particularly in the initial stages of improvement. This can be accomplished in a number of ways. One is to avoid insistence on high standards of water purity; while the water provided should be free of pollution and toxic chemicals, such treatment practices as water softening, removal of small amounts of iron and maganese, and desalting of slightly saline water can be postponed. Utilization of inexpensive materials, particularly those that can be made locally, such as plastic pipe, should be encouraged. System costs can be reduced significantly by the adoption of measures to limit the per capita quantities of water consumed and wasted. One such device is a self-regulating and relatively tamperproof faucet that is being tried out in Paraguay, Brazil, and several other countries; consumption averages 10 gallons per capita per day, and installation costs of small systems using the faucet have been less than $20 per capita.

Attention also should be given to the social and institutional aspects involved in breaking through old barriers of indifference and despair. Educational programs should be undertaken to introduce an appreciation of the value of clean water and to explain proper sanitation practices. Innovations in fund-raising methods, such as the possibility of imposing a head tax or of undertaking to sell small amounts of water for a few cents at a time, should be investigated. Public grant funds should be allocated in such a manner as to maximize the creation of an institutional base upon which fully self-supporting systems can be established at a later period of time. Arrangements for revolving credit plans such as those being implemented in Brazil and other countries should be studied.

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Goals Over Time

Obviously, the worldwide gap between existing conditions and even minimal levels of adequate service cannot be closed overnight. Development must proceed in stages over a considerable period of time, and the objectives for each stage must be determined only after careful consideration of the obstacles to progress and the resources that can be assembled to overcome them. As a guide to this process it is extremely useful to postulate national and regional goals of improved water service over selected periods of time. The fixing of goals gives direction to the national effort, compels a hardheaded analysis of all elements required, and affords a basis for assessing the extent of assistance that can usefully be provided by the world community.

One of the most impressive examples of the catalytic effect of agreed regional goals is the current effort of the Latin American countries under the Charter of Punta del Este. The charter, which launched the Alliance for Progress, is a 10-year program for hemispheric development adopted by the American States at an historic meeting in Punta del Este, Uruguay, in August 1961. Included in the document is a 10-year goal that adequate potable water supply and sewage disposal will be provided for 70 percent of the urban and 50 percent of the rural population by 1971.

Agreement on the regional goals was followed almost immediately by initiation of an organized effort to attain them. Action was started in each participating country to make a systematic analysis of the extent of the needs, the gaps in information that had to be filled, and the organizational and financial arrangements necessary to the task. One of the first steps was to strengthen the capability of the national governments to administer the program by assigning responsibility, committing funds, and establishing a competent national agency where none existed. It is particularly significant that this regional effort has been nurtured and sustained by the Pan American Health Organization (PAHO), a well-established regional organization with recognized competency in health and sanitation matters whose origins date back to the turn of the century. With the help of PAHO, periodic regional and subregional conferences have been held, helpful information exchanged, joint training courses conducted, technical assistance provided, and records of progress maintained.

Table 2 summarizes the status of the program as of 1965. The outside vertical line on the left indicates the percentage goal for urban service by either house connection or hydrant on the premises; and the line on the far right shows the percentage goal for rural service by house connection, well, or piped from a public water supply. The vertical lines in the center show the progress of each participating country in reaching these goals. Uruguay, for example, has already attained the 1971 goal for urban service, and 13 other countries are above the 50 percent mark at this near midpoint of the decade in attaining their urban goals. The participating countries are, however, lagging behind in the effort to provide improved water service for the rural populations, as only one, Costa Rica, is ahead of schedule.

Table 3 summarizes the total financial data on the program through April 1966. It is worthy of note that approximately 60 percent of the total funds expended have been derived from local sources.

Although much has been accomplished under the Charter of Punta del Este, much remains to be done. It is vitally important that the momentum already created be increased. The stated goals are only interim ones—basic service for only 50 percent of rural and 70 percent of the urban residents. The figures relate only to available water service—they do not disclose the quality of the water, the extent of the use, or the degree to which basic sanitation practices prevail.

The 1964 Seventeenth World Health Assembly of the World Health Organization (WHO) adopted the following worldwide goal for community water supplies, particularly in urban communities, as being realistic for action during the next 15 years:

(1) everybody living in a community should be provided with piped water within a reasonable distance of his home; (2) the number of people with water services on their premises should be increased to an overall figure of 50 percent; (3) adequate volumes of water should be provided through nonintermittent services maintaining at least a suitable minimum pressure at all times; (4) drinking water quality should meet suitably established national standards which can be based on WHO's international standards for drinking water; (5) administration of water supply should be independent; (6) revenues or other assured funding should provide for operation, maintenance, capital charges and depreciation; (7) adequate supervision should be provided for operation of treatment works and control of water quality.

The assembly recognized that while the general objective of providing piped water to everybody living in a community should be adopted by all countries, there are wide variations in the attainable progress in providing onpremises supplies.

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TABLE 2

STATUS OF THE WATER SUPPLY PROGRAM IN MIDDLE AND SOUTH AMERICA IN 1965

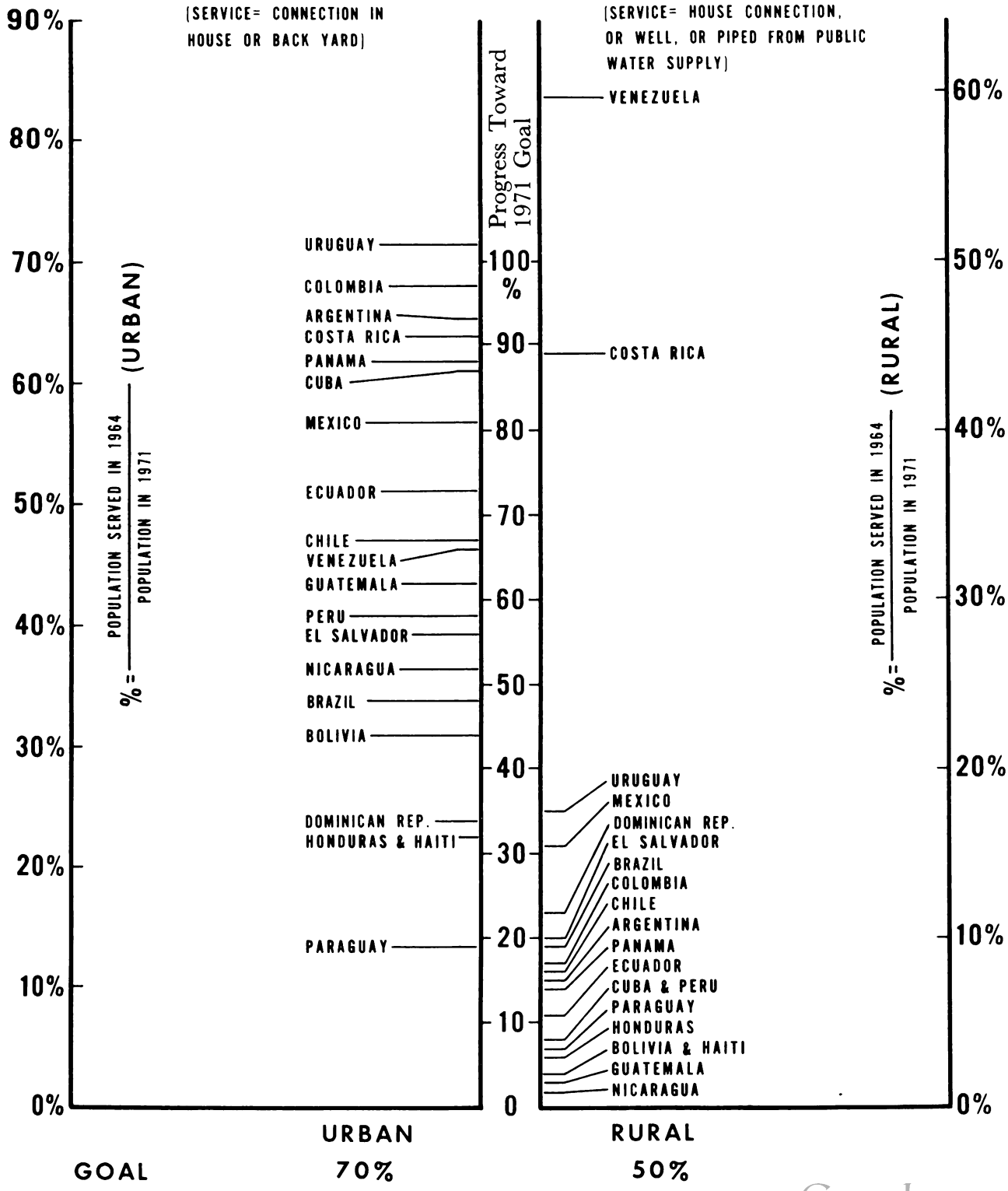

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TABLE 3.—*Summary data on the Community Water Supply Program in Latin America*

[Alliance decade (1961–71)—Report as of April 1966]

	For period 1961 to April 1966
International loans from:	
Inter-American Development Bank [1]	$289, 215, 100
World Bank group (IBRD–IDA)	24, 300, 000
Agency for International Development	36, 790, 000
Export-Import Bank	31, 522, 355
Total international loans	381, 827, 455
National funds provided to support loan projects	355, 506, 300
Additional national funds expended (without loans)	165, 000, 000
Total funds for community water supply (urban and rural)	902, 333, 755
Number of people benefited (urban and rural) [2]	46, 000, 000

[1] Includes Social Progress Trust Fund.
[2] Includes populations where projects extend or improve present systems.

NOTES

(*a*) Of total funds ($902 million), $760 million are for urban centers and $142 million are for rural areas.
(*b*) There are water supply projects in each country in Latin America.
(*c*) Total figures include small percentage for sewerage works.

National Water Supply Programs

Although urban and rural water supply must be provided and sustained at the local level, the need for strong support from national governments is an essential requisite to water progress in the developing countries. The inbred resistance to change at the community level, and the absence of traditions of private initiative and local self-help, which have created existing conditions of massive need, can only be overcome through massive and sustained programs of aid and encouragement from the national level. This assistance must include the development of national water supply goals and programs, improved planning, education and training, data collection and evaluation, financial planning, and assistance in institution formation; and it should be backed by appropriate organizational responsibility within the national government and, in many cases, the enactment of national water legislation.

Other Water-Disease Relationships

In addition to those diseases whose control may be approached in the provision of water for human consumption and sanitation, there is a group of water-related diseases, namely those for which an insect or other carrier spends an important part of its life in or on water. Measures to control these diseases are elements of water management directly affecting the health and well-being of people.

The most widely known of these diseases is malaria; eradication and control measures for which are now focussed on the application of insecticides to the walls of houses. However, there are other fly and mosquito-borne diseases, such as dengue, encephalitis, filariasis, and yellow fever where the control of waterflow and drainage are still essential control measures. This is important in regard to the elimination of environments conducive to the breeding of these insects and also in regard to avoiding potential harbors and breeding places in the design of new hydraulic facilities.

Another form of disease is transmitted by fresh water snails. In many countries, 30 to 50 percent of the total population is debilitated by bilharziasis (schistosomiasis). Irrigation adds to the danger of spreading this disease, particularly in the tropical zones. In Gezira area of the Sudan, for example, irrigation increased the number of cases of "snail fever" over a period of 15 years from 1 to 20 percent of the adult population. In parts of the United Arab Republic, the rate increased from 5 to 75 percent over the same period. Extensive research is required for the development of practical control measures for both the

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disease and the snail. As a contribution to the worldwide effort, the National Institutes of Health of the U.S. Public Health Service have conducted a broad program of basic and applied research since 1950 in the cause and control of bilharziasis, the habit of the snail vector, course of the disease in experimental animals, methods of treatment by chemotherapy, and the formulation and testing of new molluscicides for the control of the disease in the water where the snails live.

Unfortunately in the development of water resources projects, impoundments frequently are involved in the production of disease vectors. Proper consideration should be given in the development of all water resources projects for the control of impoundments in order to eliminate production of such vectors. This can be achieved in a number of ways. One of the best methods of control has been the inclusion in the impoundment works of devices which permit controlled regulation of the elevation of the impoundment in order to destroy the larvae of insect vectors which might otherwise be produced.

Water and Man's Environment

The discussion in this section of the subject of "water for living" is not complete without a final word on the significance of water as an integral part of man's total environment. The water environment which nature provides, be it drought or flood, muddy rivers or clear springs, vitally affects the quality of living and man's attitudes toward himself and the world around him: and what man does with these resources is equally important. Man also shares this environment with other living things, and the total ecological balance cannot be cumulatively disrupted without disastrous consequences. Recognition of and respect for these mutual interrelationships is essential to all sound water planning.

B. Water for Food

The Specter of Famine

Throughout human history, most of the world's people have lived in the shadow of hunger and imminent starvation. Unless food supplies are very substantially increased over the next 10 years, millions of human beings are in danger of dying of hunger. In 1966, massive efforts are being made to prevent widespread starvation in India. President Johnson, in his food for India message, asked the Congress to endorse a program for greatly increased shipments of U.S. foodstuffs and has called on other nations to join us in providing a billion dollars worth of food aid for that country. But such emergency aid is necessarily temporary and the perils of starvation will grow rapidly if the hungry multitudes of the future must look only to the same food sources that have so inadequately provided for the present population. Also there are 2 billion people today who are chronically undernourished, and as a result survive hunger only to succumb at an early age to the diseases to which their weakened condition makes them vulnerable.

Protein malnutrition is especially severe in the developing world which relies heavily upon cereals, starch roots, and sugar as its principal source of food. Vitamin and mineral deficiencies are also common in these areas.

The people in the diet-deficient areas of the world received in 1959–61 about 900 calories a day less than the people living in countries with adequate national average diets. Their daily consumption of protein was less than two-thirds that of the diet-adequate countries, and consumption of fats was less than one-third.

Some improvement is expected, however, in the quantity of food per person and in the quality in the diet-deficient areas during the rest of this decade. The calorie level by 1970 is expected to be 8 percent above the 1959–61 base period and consumption of protein and fat is expected to be up 10 and 16 percent, respectively. Much of this improvement comes from imports of food aid rather than increased production in the diet-deficient areas.

The expected worldwide calorie gap in 1970 will be the equivalent of 54 million metric tons of grain—well over 5,000 shiploads. The deficit in animal protein will likely be equivalent to 6.5 million tons of nonfat dry milk. About 3.2 million tons of soy grits would be required to fill the nonanimal protein deficit, and 3.1 million tons of vegetable oil would be needed to satisfy the fat deficit.

Filling the food gap by expanding commercial imports is most impractical for a developing country. Considering on the one hand the size of the nutritional gap and on the other the chronic balance-of-payments problems in most of the underdeveloped countries, the food gap will likely have to be filled largely within each country itself. Indeed, it is questionable if food production in the developed world could be expanded sufficiently to meet the extraordinary new demands.

The Role of Water in the Food Equation

Water, and its proper use and control, unquestionably is one of the essential factors in the global war against hunger. Agriculture, particularly under con-

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ditions of irrigation, is one of the greatest consuming uses of water. In the United States, for example, it is estimated that irrigation accounts for 85 percent of all water consumed or 46 percent of all water diverted for use. In some areas of the world the problem is too much water—in the form of floods and waterlogged soil. In others it is too little water—in arid areas, in time of drought, and during the dry seasons of the year. In many places water is wasted through inefficient use—because of improper application, inadequate drainage, archaic technology, restrictive cultural practices, and so forth.

The intelligent development and use of water, although indispensable, cannot by itself solve the world's food problems. Good water management must be combined in proper balance with the other significant factors that lead to the end result of providing more food for the starving and undernourished. The food equation consists of at least five stages: Production, harvesting, processing, distribution, and consumption. Each stage depends on the interaction of a number of elements; each is necessary to the desired result. All involve the proper harmony of resources, technique, capital, and people. It does little good to irrigate the land if the farmer lacks the knowledge and the capital to cultivate a crop. It is not helpful to harvest more fish if they spoil before they reach the urban market. It is of little satisfaction to increase yields if facilities are not available to market the food, or if the hungry refuse to eat certain foods because of social custom.

As Dr. Max F. Millikan, director of MIT's Center for International Studies, stated at a recent congressional hearing: "Agriculture is what it has become fashionable in engineering circles to call a systems problem characterized by the fact that all of the elements of the system must be present if the system is to function properly." *

At the production stage, increasing the total supply of food requires the right combination of water, soil, plants or animals, knowledge, money, and people. No single factor, standing alone, affords a cure-all. For example, the expanded use of chemical fertilizers can lead to dramatic increases in yield per acre. This has been demonstrated in North America and Western Europe, which together account for two-thirds of the world consumption of fertilizer. In other countries where yields are relatively high, such as Japan, Taiwan, the United Arab Republic and Israel, fertilizer nutrients consumed per hectare of arable land are high in contrast to the low yields in countries where fertilizers are little used. However, there is no automatic, universal ratio between more fertilizer and more food. Plant varieties that respond well to fertilizer applications in one area cannot always be transferred successfully to another area. Variations in soils, climate and local customs must also be considered.

The proper breeding, selection, and introduction of improved varieties of plants and animals is another important requisite to increased output. This is important not only in itself, but also in relation to other factors, such as pest and disease control. In some cases it may be cheaper to develop new disease-resisting strains than to control disease directly. Once new varieties are developed through research and experimentation, a long period of education may be required before the cultivators will employ them on a widespread basis. A classic example is the introduction of hybrid corn in the United States: A period of approximately 20 years elapsed before America's relatively progressive farmers put them into general use.

Many economic and cultural factors also figure prominently in food production. A high correlation can be shown in the developing world between the general levels of both literacy and per capita income and the takeoff point for sharp increases in yield. National attitudes toward the status of the farmer usually must be altered before increased production can be expected. The relationship between farm costs and farm prices often restrains advancement in countries of greatest need. In terms of the price of rice, for example, the farmer in India may have to sell twice as much rice to buy a pound of fertilizer as the farmer in the United States, and four times as much as the farmer in Japan. New financial institutions to make credit more readily available to the farmer on equitable terms must be provided. Ancient concepts of land tenure may have to be altered.

Progress in solving the problems that hold down the production of food is meaningless unless attention is also given to the harvesting, processing, distribution, and consumption stages. Agriculture is a major element in the total economic development picture, particularly in the developing countries. Deficiencies in the nonagricultural sectors of the economy must be erased. The industrial sector must supply the physical inputs such as fertilizers, insecticides, fungicides, herbicides, tractors, farm implements, tools,

World War on Hunger: Hearings before the Committee on Agriculture, House of Representatives, 89th Cong., 2d sess., Ser. W, pt. 1, at 60 (1966).

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energy, and others. Other sectors must supply such services as transportation, financing, communications, education and research. The attitudes and abilities of national and local governments must be geared to the magnitude and complexity of the task.

The world community has responded in many ways to the challenge of averting the specter of famine. Since the enactment of Public Law 480 in 1954, the U.S. Food for Peace Program shipped through December 1965, $14.6 billion worth of agricultural commodities to food-deficit nations. Today this program accounts for more than 90 percent of the total food aid extended for all countries and international agencies. The President's proposals to reshape and continue this effort as the Food for Freedom Program are pending in Congress. The Agency for International Development and its predecessor have furnished assistance. Former AID Administrator Bell recently called for emphasis to be given in AID programs on increasing domestic food production, controlling the growth of population, and fighting malnutrition.

The World Food Program under the joint auspices of the United Nations and of the Food and Agricultural Organization is engaged in coordinating international efforts to alleviate starvation and malnutrition, and the other specialized agencies have joined in the common cause. International banking institutions have made funds available for technical assistance and development projects. Many bilateral aid programs have lent assistance, and agriculture is being given heavy emphasis in country economic development plans.

The Water for Peace Program has an important contribution to render to these ongoing national and international efforts in the war against hunger. It can stimulate action in those situations where additional water or better water management is the critical need; but it cannot overcome all of the roadblocks in the way of solving the food equation. This responsibility lies elsewhere. The ensuing discussion centers, therefore, on the essential role of water in the food equation, the opportunities for development of water for agriculture and fisheries, and some of the problems involved.

Crops and Irrigation

There are some 25 billion acres of land on the earth, of which something less than 3 billion, or about 12 percent, are devoted to cultivated crops. Of this total, about 400 million acres are included under irrigation systems, and an additional 200 million acres are served by artificial drainage or protective works.

TABLE 4.—*Irrigation and drainage development in the world*

[1,000 acres]

Region	Cultivated	Irrigated	Artificial drainage
Africa	86, 600	7, 800	2, 100
Near East-South Asia	450, 200	121, 200	8, 400
Far East	98, 500	21, 800	1, 700
Latin America	606, 700	17, 200	1, 300
Europe, Canada, Japan	275, 300	24, 900	28, 700
United States of America	458, 000	33, 200	99, 100
Oceana	41, 000	1, 700	.....
Communist-bloc countries	785, 200	156, 900	44, 900
World	2, 801, 500	384, 700	186, 200

The expansion of total food output in the form of cultivated crops can be brought about generally in two ways: (1) By increasing yield per acre of already cultivated lands; and (2) opening new lands to cultivation. A recent Economic Research Service study of the experience of 26 developing countries shows that most countries that made rapid progress in agricultural output have had substantial increases both in crop yields and in area under cultivation. The development of new water supplies and improved water practices can contribute to greater food output in both situations. Since water is a limiting and usually a costly resource, it is generally desirable to plan irrigation programs for efficiency in terms of maximizing crop yields per unit of water applied, whether on existing or new projects, as well as to maximize total food output in relation to total resources of capital and human effort required. Each proposal in turn must be examined in relation to the total country program.

The opportunities for increasing yields from existing cultivated lands are frequently substantial. The magnitude of the potential can be illustrated by the fact that agricultural output in Japan in 1960 was $961 per hectare of arable land, compared with only $91 for India and $78 for Argentina. Food production in Western Europe and North America has increased sharply in recent decades while total acreage under cultivation has actually declined.

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A dramatic example of a large-scale program to improve production through better water management of an existing irrigation system is the Punjab of West Pakistan. Punjab means five waters; it is the name given to a 40,000-square-mile, essentially flat, plain traversed by the Indus River and its five major tributaries in the northern part of the Indus Plain. A complex canal system which had its beginnings in the 17th century is used to irrigate about 23 million acres annually in the Indus Plain. This is probably the largest area of essentially contiguous irrigation development in the world. Unhappily, a combination of inadequate subsurface drainage and poorly regulated application of irrigation water has resulted in more than 8 million acres being affected by salinity to some degree. Of this number, about 3.5 million are seriously affected, including 1.5 million acres that are out of production. Salinity has been encroaching upon new lands at the rate of about 100,000 acres per year, of which about half goes out of production. Furthermore, crop yield from unaffected lands are only a fraction of world averages owing to the improper application of irrigation water.

The salinity and drainage problems have been a matter of increasing study and concern by the Pakistani for many years. As the result of comprehensive water and soils studies carried on over a number of years, including participation by a number of United States experts, the West Pakistan Water and Power Authority has developed a plan for the amelioration of drainage and salinity problems and reclamation of unproductive lands. Investigation revealed that virtually the entire Punjab is underlain by an alluvial groundwater reservoir, about two-thirds of which is saturated to an average depth of 500 feet or more with water of acceptable quality for irrigation. The amount of usable groundwater in storage at any one time is estimated to be 2 billion acre-feet, which is equivalent to slightly more than 12 years of runoff of the entire Indus River system. A major source of recharge to this reservoir comes from leakage from the canals; it is estimated that one-third of the waters diverted to the canals is discharged in this manner. Basically, the plan for the reclamation of the Punjab relies on utilization and management of the vast underground storage reservoir through installation of a network of tube-wells at an average density of one per square mile. Pumping from the tube-wells will be used to control ground water levels to prevent waterlogging. For example, on one large-scale tube-well irrigation and drainage project located in Rechna Doab of the Punjab region, the water table was lowered more than 5 feet beneath a 1.3 million acre tract between 1961 and 1965 by pumping from some 1,5 tube-wells. Concurrently, agricultural productic more than doubled on the reclaimed tract. Whe waters pumped from the ground are of satisfacto quality, they will be used for irrigation; if not, the will be discharged to waste. Leakage from existin canals will be allowed to continue in most cases as a important source of recharge to the subsurfac reservoir.

Another aspect of water management relating t food production is flood control. For centuries, mar has relied upon seasonal floods to provide both mois ture and nutrients to the soil as a basis for farm culture In some cases, particularly in arid areas where the lo total annual rainfall is concentrated in a short period of time, the flood waters can be used more efficiently by the construction of simple facilities to spread the flooding water over selected lands and by planting fast-growing crops to take advantage of the moisture.

In most cases, however, reliance on natural flood patterns is an inefficient use of water and land. The very floods which bring the life-giving water frequently destroy growing crops as well as homes and people. A 1955 flood in East Pakistan, for example, washed away nearly 75,000 head of cattle; the record 1937 flood in Cambodia resulted in damage to crops ranging from 80 percent to complete destruction. Various measures may be taken to lessen flood damage to crops and livestock, such as watershed management, channelization of the river course, the construction of levees, and better use of the flood plain, which when coupled with adequate flood warning systems, can permit emergency measures to be taken to reduce levels of destruction. The most dramatic control measure probably is construction of large mainstream storage reservoirs, such as those constructed on the Colorado River in the United States and Aswan Dam on the Nile in Egypt, which not only reduce direct damage but also provide stored waters to support irrigation development.

Although large-scale projects like those described have great popular and political appeal, investigation often reveals that smaller, less costly programs and projects afford a more efficient use of limited physical, monetary, and human resources to increase yields. These include provision of supplemental water supplies; upgrading operation and maintenance of existing systems; improvement of on-farm facilities for applying irrigation water efficiently; training in proper use of water; reduction of sedimentation loss in reservoir storage capacity; and spreading of seasonal floods

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in arid areas to conserve moisture for fast-growing crops.

While the worldwide potential for increasing food production through cultivating new lands, and thereby expanding the total economy, is great, so are the problems and restraining considerations. In global terms, the areas of greatest population concentration and greatest need, such as in much of south Asia, are the areas where the opportunity for expanding cultivated acreage is most limited. If the capital and human resources are made available to produce food from other regions, provision would also have to be made for transportation and distribution of the food at great distances in order to get it into the mouths of the world's hungry.

From the point of view of soil capability alone, it is theoretically possible to double the cultivated acreage. In some areas where adequate soils exist, however, excess water limits production, and drainage and flood control works are necessary. In humid tropical lands, special and often costly measures would be necessary to sustain agricultural production.

In arid and semiarid areas, the absence of available moisture in any form is often an unconquerable limitation. Elsewhere, modern technology does make it possible to bring water to the arable lands, through development of ground-water sources, storage of seasonal floods, or transbasin diversions. This is true, for example, for regions in South America and Africa of low population density where the annual cycle produces heavy rainfall at one season and drought during the remainder of the year. However, the problems to be solved other than technological ones, are considerable. For one thing, irrigation projects are costly. Construction of irrigation and drainage works by modern, efficient methods may require expenditures of $500 per acre, and often considerably more. Also, difficult programs must be undertaken to provide population resettlement, education and training, institution building, and transportation facilities.

Livestock and Range Management

Livestock are an integral part of most advanced agricultural systems and are efficient converters of grass and plant wastes. A large share of the total feed for the world's livestock comes from pastures and rangelands. The world's natural grasslands have been largely taken for granted, although they constitute some 64 percent of the total agricultural area. But the growing importance of livestock in many developing countries has made it impossible to continue this neglect. Mismanagement of grazing lands has accelerated serious soil and water losses. These, in turn, have contributed to downstream flooding and siltation, simultaneously reducing the amount of grazable forage on the land itself. Much of southwest Asia's grazing lands is seriously depleted as is much of northern Africa's where rainfall is limited. These grasslands are not only low in fertility but are severely eroded.

In order that rainfall be used most effectively for forage production, it is essential that the vegetative cover be restored. In the semiarid or subhumid areas of northern Africa and southern Asia, restricted grazing, or in some cases reseeding, may be needed. In the more humid areas, proper grazing management, reseeding with improved pasture species, and fertilizer are needed.

Other important measures required to make effective use of water and improve the grazing lands include: grazing in accordance with seasonal growth, fencing for grazing control, and developing stock watering places to permit a more uniform grazing pattern. Supporting water conservation measures such as dams, diversions, and contour furrows may also be needed. In many countries of the Orient, the entire land tenure and land use systems may have to be readjusted. Restrictions on the time at which livestock may be grazed, and on the number of livestock that may be grazed will be necessary.

Fisheries

The oceans, rivers, and lakes comprise another source of animal proteins, yielding over 56 million tons in 1964. It is significant that 30 million tons, or well over half the catch, was landed by the developing countries. In addition to contributing to the nutritional balance of local diets, these fish were important exchange earners for the nations involved. Approximately 6.5 million tons were harvested from fresh water areas; and of this, 5.5 million tons were harvested in the developing countries.

During the decade 1955–1965, the world's fishing fleets increased their landings by 70 percent. The following table shows fish catch by regions in 1964.

The steady increase in landings over the past decade is one of most encouraging events in man's urgent search for food sources. There is evidence to support the belief that further large gains are possible. As recently as 1961, a group of the world's most eminent biologists discussed the ultimate useful level of productivity of the world's water areas. While there was wide variation in the estimates made, the moderate estimates postulated an upper limit of 500 mil-

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TABLE 5.—*World fish production, 1964*

Region	Production (million tons)
United States	2.9
Canada	1.3
Japan	7.0
Europe	10.6
U.S.S.R	4.9
Near East and south Asia	3.3
Latin America	12.7
Africa	3.2
Far East	10.0
Total	56.7

lion tons of fish annually including a tenfold increase of the fresh-water catch to 71.4 million tons.

Although the production of food from the oceans is outside the scope of the Water for Peace Program, the production of food from fresh-water areas is an important aspect of the program because of its close interrelationship with good management of water and land to maximize food output. The fresh-water areas of the world have a surface area of about 12 billion acres. They include not only natural lakes, ponds, rivers, and artificially constructed waterways, but also river estuaries, closed lagoons, bays of the seas (brackish water areas), and paddy fields submerged for 3 to 8 months per year. The productivity of fresh-water areas for fish production, when properly managed, exceeds that of the land. Yields as high as 9,300 kilograms of fish per hectare per year have been realized. The contribution of this potential yield to man and the need for study and management of the aquatic environment are obvious.

The cultivated ricefields of the world cover 240 million acres and represent an ideal opportunity for multiple use of water through fish farming. The present average fish production figures for the largely unmanaged fresh-water areas is 480 pounds per acre per year. Highest production figures, in Africa, have surpassed 8,500 pounds of fish per acre. Certainly, using only the average production figures cited above, the potential fish production from the 240 million acres of cultivated rice paddies, or 115 billion pounds of fish, would justify all efforts necessary to bring about a sustained top annual productivity from the fresh-water areas. As another method for increasing fish production, salt marshes can be excavated, diked, and flooded by sea water or brackish water controlled by sluice gates. The periodic flooding assures a supply of highly oxygenated, nutrient-rich water. Native fish populations enter the opened gates and, becoming established in the ponds, grow fast in a nonstressed environment. The heart of the job of brackish water fish culture is to control the ecology of the system so as to improve the yield of the desired species.

One of the most exciting and promising means of using fish to supplement protein-deficient diets is production of fish protein concentrate—an inexpensive, spoilage-resistant, odorless, tasteless, high-protein powder which could be processed from many kinds of fishes and be blended with virtually all traditional food preparations. Daily consumption of 1 ounce of the powder, with a nutritional value equal to that of eggs and costing about 2 cents, would supply all of the individual's daily requirements for animal protein. Although developmental efforts to date have been directed primarily toward production in the United States by one of the three basic processes by which the concentrate may be made, and to marine species of fish, future production may be by any one of several processes and might include extensive use of fresh-water species. With refinement of processing methods, smaller plants, possibly even portable, would make it possible to produce fish protein concentrate in many areas throughout the world. If these developments occur, production of fish in fresh-water reservoirs, rivers, lakes, ponds, and in brackish water areas will assume much greater importance.

C. Water for Commerce and Industry

In his Water for Peace address, as well as in his messages and statements relating to foreign aid and international health, education and food programs, President Johnson has placed primary emphasis on the basic human needs to eliminate hunger, disease, ignorance, and poverty. The preceding parts of this chapter have discussed the vital contribution which water development can make to these efforts. It is universally recognized, however, that man's individual human progress is inextricably dependent upon the total economic and social progress in the community, nation, and world in which he lives and works. Water for living and water for food are inseparably interrelated with water for commerce and industry as a part of the total environment for human progress. Accordingly, these other important beneficial uses of water must also be

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considered in a survey of the total human needs and opportunities relating to water development.

Water for Industry

Just as water is vital to human life and happiness, so also is it essential to the industrial processes that must be counted upon to provide a higher standard of living for all and to answer the worldwide revolution of rising expectations. With the possible exception of agriculture, industry is the greatest consumer of water. In the United States, for example, it is estimated that industry itself provides for its own use (not including hydropower) 46 percent of all water supplies utilized each year, not to mention the substantial portion of public water supplies that serve commercial and industrial purposes.

The industrial uses of water are as varied as the intricate kaleidoscope of industrial processes themselves. Water is extensively used in the minerals industry—in hydraulic mining, the reduction of ores and the refining of oil, for example. It is used in all chemical processes—such as in the making of paper and plastics. The processing of crops and fish for distribution requires water. Water is used by industry for washing, for heating, for cooling, and for a thousand other purposes, some familiar, many exotic.

Quality requirements of water used by industry vary widely. For most industrial processes, however, water that meets drinking water standards is acceptable. Because of the volume and quality of the water required, industrial users frequently develop their own water supplies. In doing so, they often pioneer in knowledge and technology that can be of considerable value for public systems. In this connection, it is noteworthy that most of the desalination plants in operation throughout the world today have been built and operated by private industry, primarily by oil companies, for community water supply as well as industrial purposes. Where a plant or firm obtains water from a public system, it usually is in a position to pay the full costs of development and delivery of the water used.

The use of water for commercial and industrial purposes has the advantage of being largely nonconsumptive, that is, after use in the industrial cycle, much of it is discharged to a river or other watercourse and is potentially capable of reuse thereafter. Unhappily, the discharged water all too frequently is altered by chemical, thermal, or other industrial pollution; and the elimination or control of this pollution is a major problem of water management that has become particularly critical in the highly industrialized countries.

Water Transportation

Civilizations have almost invariably grown up along rivers, lakes, and oceans which offered the facility for easy and cheap transportation of goods. Even at the highest level of economic development internal waterways are an important means of transportation. Many of these waterways could be made much more useful by dredging and silt control. Others will benefit from such measures as large storage projects which may permit year-round navigation otherwise possible only during the rainy season and where feasible, systems of locks around navigational obstacles. The improvement of port and harbor facilities is frequently closely related to any large-scale development of rivers for navigational purposes. Although great efforts have been made through the centuries to develop inland waterways as avenues of commerce for man's benefit, the opportunities for further development are enormous.

Hydroelectric Power

Everywhere in the world, including the undeveloped nations, the demand for energy is climbing steeply upward. This is especially true of electrical energy. Historically, the consumption of electrical energy has more than doubled for each of the past several decades and no diminution of the trend is evident. Gross world electric power consumption amounted to just over 3 trillion kilowatt-hours in 1964, an increase of 8 percent over the previous year. It is evident then that for countries blessed with conditions suitable for its development, hydroelectric power, especially when developed in concert with other purposes such as flood control and irrigation, can be a primary means to rapid growth. Water in substantial quantities also is used for cooling purposes in thermal generating plants, and its use for pumped storage projects is developing at a significant rate.

Hydropower is estimated to account for roughly a third of all electricity generated in the world. Excluding the United States, it may account for as much as half. Although the cost of hydropower installed capacity is almost always greater than equivalent thermal capacity, operating costs are invariably much lower. Much of the installation cost of hydropower stems from its proportionate share of the cost of dams which in some cases can be built with indigenous labor and materials. Thus, the requirement of foreign exchange may be less than it would be for thermal installations which require a substantial import of equipment from developed countries.

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Hydropower is almost always developed in association with some other potential use which in many cases requires energy for its full exploitation. For example, electric power may be used in the manufacture of chemical fertilizers for use on the land irrigated as a result of the hydropower complex. In some developing countries ore deposits of economic significance exist which require the development of power-intensive mineral extractive industries for exploitation. Examples are the refinement of aluminum metal, extraction of titanium or zirconium, electrolytic copper production, and in smelting of nickel by use of electric furnaces. The techniques of using electric power in such industries are well known and can be quickly exported to countries where conditions are favorable.

Recreation and Tourism

One of the basic problems of the developing countries is to obtain adequate foreign exchange in order to buy the goods and services needed for development. Acquisition of this exchange in many cases could be enhanced through tourism by exploiting the worldwide interest in travel and in vacation areas having some unique appeal. Many nations have scenic wonders and places of historic interest, or wildlife which can be seen or hunted in its native habitat. Dedication of headwaters areas having outstanding scenic or scientific values as national parks or nature reserves may serve not only to preserve the water quantity and quality characteristics of the region and provide benchmark areas for scientific study, but will provide significant economic benefits from tourism as well, such as the Guatopo National Park in Venezuela. Favorable combinations of sun and sand and sea await only the provision of water supply to make many areas attractive seashore resorts.

Water development can be made to aid tourism and recreation in several ways: Improving the quality and availability of water for public accommodations, stabilizing flows and otherwise improving the quality and attractiveness of streams, adding to the supply of recreational waters by construction of ponds and reservoirs, and contributing to the development of an attractive setting in the total environment. Many small countries with little else to exploit make a business of selling their uniqueness, their scenery, and their historic appeal to tourists the world over.

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III. RESPONDING TO THE NEEDS AND OPPORTUNITIES

Chapter II has reviewed in summary form the end benefits which water can provide in man's pursuit of happiness. Water is vital for life itself—for drinking, for cooking, for bathing, for the sustenance of bodily health, and the elimination of disease. Water is essential to the production of food through agriculture and fisheries. Water development is one of the fundamental bases for the economic progress necessary to eliminate poverty and to provide a better life for those who desire it. Lastly, water is an integral part of man's environment, and the extent to which it is clean or polluted, beneficial or destructive, present or absent, significantly determines the quality of living.

Although water affects man's welfare in these many ways, water as a resource is indivisible. One cloudburst may moisten the soil, fill a cistern, and wash out a bridge. Water drawn from a single well may be used for drinking and cooking, for watering stock, and for irrigating crops. Water put to one use may be used again and again for other purposes before it reaches the sea. One dam may simultaneously serve the purposes of navigation, flood control, municipal and industrial water supply, irrigation, hydroelectric power generation, fish and wildlife, recreation, and water quality control.

No discussion of the subject of water is complete, therefore, unless, in addition to looking at it from the viewpoint of man's needs and benefits, the subject is also reviewed from the viewpoint of the resource itself and of the programs necessary to develop it in the service of man's welfare. Accordingly, chapter III turns to a discussion of the development and control of water resources and of the steps that must be taken to mobilize the resources of knowledge, people, materials, and finance to attain desired results.

A. Development and Control of Water Resources

Multiple-Purpose Development

Up until this century nearly all waterworks were built for a single purpose: To provide power for a mill, to impound water for a town's use, to provide a means of transportation, to divert it for irrigation, to prevent floods, or dispose of waste. As a result, these separate and unrelated ventures contributed nothing to one another's effectiveness, and quite often interfered with it. Thus, a dam might be built for municipal use that was too low for power generation or too small for the additional demands of industry.

Gradually the realization evolved that many of these disparate purposes were indeed compatible, and that quite often it was perfectly possible to build a dam that would not only provide water for irrigation, for industry and for electric power, but could also serve beneficially the purposes of navigation and flood control as well.

Thus the notion of multiple-purpose development of water resources grew, and rapidly so after the Tennessee Valley Authority proved such an outstanding success. At the same time, there also developed an increasing awareness of the interdependence that exists among the inhabitants of a common drainage basin and the rather tenuous balance between the forces that continuously operate upon the basin's land, water, vegetation, and animal life.

For example, it matters greatly to the downstream community what its upstream neighbors put into the water as it goes by them and the amount of it they take out may matter even more. Erosion is not merely the concern of the landowner whose topsoil disappears down the gullied hillside. The silt fills the reservoir of the neighboring town, and the runoff rushes down the bare land to flood the farms and villages below. Hence the ramifications of water management spread quickly to such related concerns as afforestation and soil conservation.

Whole-basin development, through a series of carefully integrated, multiple-purpose undertakings, is one of the best methods to develop the water resources of the world. In many ways it is made easier in nations that are largely undeveloped: few essential locations have already been claimstaked by single-purpose projects, as is so often the case in developed nations. There

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are difficulties, of course, especially the need for great initial outlays of capital. Vast amounts of data are needed, much of which is not available and its collection may require years. Far reaching changes are required on the part of the people who will be the prime beneficiaries.

Upstream Watershed Management

The upper reaches of the drainage pattern may be a desirable place to begin development of a basin's water and related land resources. In some cases upstream development can be started and carried out on a smaller scale than downstream development in the same basin. Other reasons for considering upstream development are that upstream works are simple and cheap, are within the nation's technical capability, make maximum use of local resources and minimum demands on foreign exchange, can be initiated within a short time after planning and can be completed in a relatively short time. Upstream developments can sometimes meet the nation's or region's first and most pressing need for water, and they give strong impetus toward improved agriculture, improved land management, and needed improvements of soil conservation.

The actual process of developing watershed plans requires a team effort. The technicians usually needed are engineers, hydrologists, economists, geologists, soil conservationists, and foresters. Other specialists, such as biologists, agronomists, and soil scientists, may be involved to a lesser extent. The result of their combined efforts should provide not only the alternatives for development; it should furnish decisions as to (1) the program of land treatment and structures which will be carried out, (2) the schedule of installation, (3) agency or organization have responsibility, (4) arrangement for financing, and (5) arrangments for operation and maintenance.

Flood Control

Great masses of people in the developing countries, particularly in Asia and the Far East, live in vast flood plain and deltaic areas so that their very existence and livelihood are closely geared to their accommodation to the flooding characteristics of the streams and to their efforts to create some measure of protection from the destructive effects of floods. The millions of acres of land in these areas are rich in top soil washed down from the upstream watersheds through centuries of erosion and are intensively cultivated for food production. Uncontrolled flooding results in loss of life, damages to crops, dwellings, and other properties, contamination of water supplies, the spreading of water borne diseases, and the disruption of orderly social and economic processes. The preemption of flood plains and deltaic areas by flood waters during certain seasons of the year precludes their full use for needed food production and economic growth. In addition, highwater normally complicates the movement of food and other traffic via the navigable waterways.

The inhabitants of many of these areas, through centuries of painful experience have learned some degree of accommodation to the frequent overflow of floodwaters into their living and producing areas. Despite the erection of barriers and levee systems to protect against flooding, major floods continue to cause extensive damages and prevent full utilization of the land; large areas have not been protected, or have received only limited protection, and much remains to be done. Some of the steps which have been taken included the clearing and maintenance of river channels to assure the passage of floods without obstruction and the protection of banks by revetments, but these measures alone are rarely effective in bringing more than minor relief.

In still other areas of the world, particularly in Africa and South America, the large flood plain and deltaic areas of the great river systems are largely unoccupied and undeveloped when compared with the Asian and Far Eastern countries. Some of the rivers are so very large, for example, the Amazon, that their control must be put into the long range future. Nevertheless some portions of the areas subject to overflow, particularly adjacent to the tributaries and smaller streams, can be developed or improved if provided with a reasonable degree of flood protection.

The long range objective in the control of rivers and streams is to maximize the net benefits, to the extent practicable, from development of the land and water resources for all purposes necessary to meet man's future needs. Such an objective can be advanced through systems analyses of the effectiveness of the various control and development measures, both in the upstream watershed and on the main stem and principal tributaries of the river system. These measures include multiple-purpose reservoirs to store floodwaters and use them for power, irrigation, improvement of navigation depths and of water quality. They also include local flood protection works, levees, floodwalls, channel stabilization measures, and bank protection. Additionally, there are nonstructural measures, such as flood-plain zoning and flood-warning systems, which should be considered in the analyses. It is essential that sufficiently large storage capacity be provided in the reservoir system to prevent dis-

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astrous flooding in the downstream areas. Flood control is the key to realization of other water related benefits.

A systems analysis is now being carried out in the planning for the control and development of the great Mekong River system through the cooperation of the countries directly concerned, Laos, Thailand, Cambodia and Vietnam, and the cooperating countries associated with this effort. It will not be practicable to bring the river under control by simultaneous construction of the necessary engineering structures; rather, a step by step phased plan will be developed which will permit gradual control over this mighty river.

An example of another area urgently in need of flood protection is the flood plain and delta of the great Ganges-Brahmaputra River system in heavily populated East Pakistan. Dams would be required on the Brahmaputra River and tributaries in India to store flood waters which would be used to generate hydroelectric power, improve navigation and provide irrigation water during the dry season. Through this procedure, as well as construction of local flood protection works in the downstream area, it would be possible not only to alleviate much of the suffering and property losses due to floods but to augment food supplies through year around cropping practice where only one crop per year is now possible.

Many overflow areas in the developing countries of the world, such as the one cited in East Pakistan, can be greatly improved for man's use through the construction of the more immediate, less costly, flood protective works in advance of the principal control systems. While these are only a palliative, and there are inherent dangers in providing only partial protection, in many situations substantial economic returns can be achieved. A survey of each country's problems and needs, together with the gathering of basic data, would be required to pinpoint the location of such works.

Ground Water Development

Ground water in quantity and quality adequate for livestock and small village water supplies is widely available in the rocks and sands of the earth's crust. Even unfavored regions of relatively impermeable crystalline rocks, such as occur widely in the Indian subcontinent, central and southern Africa and eastern South America, contain some ground water. This widespread availability plus other inherent advantages, has led to emphasis around the world in development of ground water for pastoral or livestock use, as well as for community water supplies in villages and towns up to populations of several tens-of-thousands.

In most of the vast arid regions of the world, such as the Arabian Desert, the Sahara of north Africa, and the Atacama Desert of Chile, ground water may constitute the only reliable source of water supply. Many of these desert regions, as for example the Sahara and the Arabian Peninsula, are underlain by extensive and productive ground water reservoirs or aquifers. However, most of the water in storage in these aquifers has probably accumulated during wet climatic cycles of the geologic past, and the aquifers are not being substantially replenished under present arid conditions. Thus, any moderate- to large-scale ground water development from such aquifers, e.g. water for irrigation or industry, must provide for eventual depletion of the resource. Typical of such ground water developments of finite life expectancy is the New Valley project in the Western Desert of Egypt. Here, about 100 deep (400 to 800 meters) wells have been put down to tap artesian aquifers in the Nubian sandstone. These wells, which originally flowed at land surface are now being equipped with pumps to irrigate about 100,000 acres of desertland. Eventually, and with protracted pumping, water in these wells will decline to a level of uneconomic pumping lift.

In more favored semiarid regions drained by large river systems such as the alluvial plains and valleys of the Ganges, Indus, Tigris-Euphrates and Nile, ground water drawn from large-capacity wells is a very important water source for irrigation and other large-scale use, supplemental to water diverted from the rivers by barrages and canals. The ground water reservoirs in these regions are replenished year after year by infiltration from rivers, canals, and return seepage from irrigated fields, as well as to some extent from scanty rainfall. Such ground water reservoirs can be considered perennial and, with appropriate management, will support permanent agricultural and other development.

Many of these fertile plains and valleys, traditionally irrigated by canal diversion from rivers, have developed waterlogging and soil-salinization problems as a result of poor subsurface drainage and rising water tables. The project for reclaiming such lands in the Punjab region of the Indus Plains has been discussed in chapter II, and similar irrigation and drainage projects based on tubewell networks are now underway in additional areas of the Indus Plains of West Pakistan. Comparable benefits in improved agriculture and increased food production could be derived from such

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projects in other waterlogged and salinized lands where similar conditions exist.

The need for information on ground water resources in the developing countries is so important that further activity of the United Nations in this area should be encouraged. This might take the form of a systematic program of assembling, compiling, and publishing available information and data relating to the extent of these resources and the need for further exploration and development.

Pollution Control

So much attention has been devoted to increasing and conserving the amount of water available for use that sight is lost of the fact that if water quality is sufficiently degraded, it becomes unusable, and the effect is therefore the same as a quantitative loss. The problems of water quality and water quantity are therefore inextricably interwoven. The control of water pollution may thus become the overriding consideration in providing adequate water supplies for continued national growth, health, and welfare. The limited supply of water relative to the demands made upon it, now and increasingly in the future, requires that its quality be maintained for repeated reuse by each downstream community, industry, farm, and recreation area.

Pollution comes from many sources, and because this is so, its abatement requires many different types of action. It has been vastly accelerated by the large increases in population, and ironically by the very measures people have taken to improve their standards of hygiene, nutrition, and public health. Organic wastes, laden with infectious agents, conveniently removed from one city are distributed often with insufficient treatment to the localities downstream. The enormous chemical residue that remains in the water used to wash and otherwise treat certain materials in industrial processes does grave damage to the natural chemical balance of the stream further down, and ambient temperature of rivers may be raised several degrees by the heat-laden discharge of plants which use water for cooling. Farmers who use large volumes of pesticide and chemical fertilizers may likewise contribute to the problem of maintaining water of sufficient purity for reuse downstream; and irrigation return flows often degrade the quality of the water in the stream. Water transportation also can result in pollution from shipboard wastes and oil discharges. It is thus obvious that both developing and developed nations have pollution problems.

Pollution is, in many of its aspects, a consequence and cost of civilization and economic progress, and having the bitter lessons of the developed nations before them, the developing nations may be able to avoid the same mistakes as they proceed with their development programs.

Further, it must be recognized that, with population increase, there will be a tremendous competition for the use of inland or estuarial water, with the temptation to use these waters for disposal of domestic or industrial wastes. The problem of contamination of marine estuaries particularly is of profound concern, since these are the most productive fishery areas of the world saltwater system.

Experts are in general agreement that the water pollution abatement objectives of a nation or area can nearly always be met—at a price. The fact is that developed nations are only now recognizing that pollution abatement is an integral cost of water use, and that concentrated and continuing efforts must be made through appropriate techniques to finance it.

Streams have an inherent though limited ability to cleanse themselves of certain pollutants through the oxidation of organic matter aided by microorganisms that make their home in the water. In some cases this self-cleansing action can be enhanced. The treatment of sewage can be very greatly improved in many localities. The release of contaminating agents into streams by industry can be vastly reduced by strict control measures. The indiscriminate use of toxic chemicals for agriculture can be curbed, and new and less objectionable ones developed. In the end, of course, some pollution is unavoidable, but there are many reasons to believe that it is actually but a small fraction of the amount which is presently being permitted. Future pollution control measures may appear to be very costly, as indeed they will be when compared to those of the past, the difference being that future payments must also carry the long-deferred charges that past users of water resources have haphazardly passed on to their successors.

For the United States, development of techniques, laws, and practices to control pollution of all kinds threatening our cities and rural life are a matter for urgent action. The same problems of pollution in an industrialized nation are also found in other advanced nations, particularly in Europe. Some of these nations are ahead of the United States in one phase or another in protecting their water supply, and all would benefit from sharing their combined knowledge and from participating in joint research and study efforts to develop additional knowledge and put it to use.

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In the developing countries the most urgent problem in water pollution control is the reduction in water-borne and water-related diseases. But other problems of agricultural, industrial and urban pollution exist or imminently threaten, and control measures must be planned for and instituted as rapidly as feasible.

The International Conference on Water for Peace, which the United States will sponsor in 1967, will provide an opportunity for all countries to exchange ideas on problems of pollution control that confront an area at each level of development.

Desalination

In those places in the world where natural supplies of water of adequate quality in adequate amounts are not available at economically feasible costs, man has always been interested in the possibility of deriving fresh water from the sea or from inland sources of brackish water containing dissolved salts at levels too high for normal treatment and use.

As the result of intensive research and development efforts in a number of countries in recent years many advances have been made which demonstrate expanding opportunities for utilizing desalting technology in water-scarce locations. The First International Symposium on Water Desalination, held in Washington in October 1965, brought representatives of more than 60 nations together for discussions on all aspects of the problem of making saline water useful to mankind.

Fresh water may be processed from saline water by several means. One group of processes separates water from its dissolved salts either by distillation or by freezing, but the capacity of water for storing heat is so tremendous that large amounts of energy are required to change it from a liquid to a vapor or a solid to accomplish the separation process. Of the two processes, distillation has long been used, and accounts for most of the installed capacity today. The heat energy required may be supplied by nuclear reactors or by burning oil, gas, or coal. In sun-rich areas, solar energy may be used for small plants where other heat sources are uneconomical or unavailable. The freezing process theoretically requires less energy than does distillation, but at present the technology is not as far advanced.

A second group of processes separates the dissolved salts from the water by utilizing membranes. Of these, electrodialysis already has practical application in more than 100 small plants throughout the world and is particularly useful for brackish water. Reverse osmosis is theoretically the most efficient known process, and is showing great promise for brackish and perhaps sea water as it moves into the pilot plant phase of development. The membrane processes have a capability of partial purification, a feature of particular advantage where only a portion of the salts of brackish water need to be removed to make it useable, as in the case of a municipal water supply.

Other processes, such as ion exchange, are currently under investigation and with further development may have useful application in certain circumstances.

Cost is inherently the most important consideration in determining the extent to which desalination should be adopted as a method for providing water at a specific location at any particular point of time. The cost of making water available from a desalination plant depends on a number of interrelated factors, including the degree of salinity of the water source, the process or combination of processes employed, the possibilities for blending high-purity water from a desalination plant with lower grade water from other sources, the cost of energy, the cost of money, the method of brine disposal, the separation in distance and elevation between the water source and the market to be served, and the rate and amount of use of product water over the working life of the facility.

Between 1953 and 1966 the at-plant cost of desalted water in the United States dropped from $5 per thousand gallons to costs in the range of approximately $0.75 to $1.50 per thousand gallons ($245 to $489 per acre foot) for plants producing a million gallons per day or less, and additional reductions are anticipated with improved technology. Similar cost levels have been attained in plants overseas. The prospects for further economies are especially favorable in the case of large dual-purpose thermal plants which use high pressure steam to produce electricity that can be marketed profitably and at some point extract the low pressure steam to provide energy for the water conversion plant. Recently, agreement was reached to construct the world's largest plant of this kind, to be located on a man-made offshore island near Los Angeles, California. The plant, utilizing nuclear fuel, will produce 150 million gallons per day of fresh water and 1,800 megawatts of electric power. The average water cost at the plant will be approximately 22 cents per thousand gallons.

Once the cost of producing water by desalination at a specific location has been ascertained, it should be weighed against the need for water at this cost and against the comparable cost of supplying water by alternative methods, such as from wells and rivers and by water reuse and conservation.

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It often is extremely difficult to establish complete comparability of costs between desalting and alternative operations for producing additional supplies of water. Preliminary studies have been made by the United States, the United Nations, and others to identify locations where desalination might be considered as an economically feasible method for producing needed supplies of fresh water as an alternative to, or in combination with, conventional methods. It is evident that comparative costs of conventional methods for water supply (not including distribution systems) will be found to vary widely throughout the world. In some locations under ideal conditions this cost probably is less than 1 cent per thousand gallons ($3 per acre foot); in other locations at the high end of the scale it exceeds that of desalination. In general, although the cost of producing water by conventional methods in the quantities required for world needs is substantially less than the cost of desalination, desalting costs are now approaching levels which industry and municipal customers are able and willing to pay in a growing number of water-scarce locations. It also is possible that future lowering of production costs may under special circumstances permit economic agricultural use of desalted water to irrigate high-value crops.

A number of additional factors besides cost of production also need to be considered in assessing applications for desalination. An important factor is the value of advancing the technology, particularly in realizing the economies of large-scale production. The time factor is relevant, especially in areas where the unreliability of water supply has contributed to economic stagnation, or where other resources can be developed if water is available even at a relatively high cost. Political realities and cultural attitudes also figure in decisions as to which method or combination of methods should be relied upon over given periods of time.

Three areas of particular applicability for near-term action in desalination would seem appropriate. The first is small- and medium-scale plants, including solar stills, to satisfy requirements of isolated communities without other recourse. Second, are desalination plants to serve communities where acute water shortages exist, or occur unexpectedly, or communities where the lack of adequate quantities of water of satisfactory quality has imposed severe economic stagnation. They would be utilized while comprehensive studies and programs are conducted to locate and develop alternate sources of supply, or until existing sources are repaired or replenished. Once replacement water supply becomes available, these plants might be held on a standby basis or dismantled and moved to other areas of critical need. The third category comprises the very large, generally dual-purpose plants, whether fueled by nuclear or conventional energy, which hold promise of bringing down costs of desalted water to economically acceptable levels. As to the last, however, the high capital costs would suggest a careful, case-by-case analysis rather than any across-the-board approval. Such an analysis should, of course, take into account political, technological, commercial and other pertinent factors, as well as strictly economic considerations.

Weather Modification

The National Academy of Sciences and the National Science Foundation have recently released independent evaluations of the potential of man to modify weather and climate by choice and also inadvertently. In the specific area of precipitation increase, most optimism is expressed with respect to augmenting orographic precipitation on the windward slopes of mountains. Several U.S. agencies plan to support substantial research in this area. There is also much research being conducted in weather modification in other developed countries. There is a significant need for the exchange of knowledge and coordination of new research efforts both within the United States and internationally.

The Economics of Water Development

A number of economic and financial considerations, interwoven and interacting in a complex system of economic analysis, are involved in selecting and planning water development programs. These may be grouped under the headings of national economic policy, reimbursement policy, and project evaluation. Although each of these factors is important, and over stated periods of time all must be considered, it must be recognized that economic planning is at best an inexact science and that at any stage and with respect to any decision, commonsense judgments must be made on the basis of inadequate or nonexistent information and of deficiencies in understanding the economic forces at work.

Informed judgments as to individual water programs cannot be made in isolation from overall national economic policy. Water development must be placed in its total economic perspective. It is important that consideration be given to the location and opportunities for development of land, mineral, and other resources as well as water. Resource complexes must be considered as an interrelated whole, and some

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concept of the direction in which development desirably should take place should be in the minds of the economic planners even if only in a rudimentary form. In most developing countries agriculture constitutes a significant base for national economic strength, and agricultural development should be assessed in this light in determining priorities for water development. A further critical problem in most developing countries is the limitation on available foreign exchange, which must be expended where it will make the most efficient contribution to total economic development. Restraints of historical traditions, cultural values and political necessities that affect economic activity cannot be ignored. Water projects must also take into consideration the value of their contribution to such objectives as maintaining peaceful relations with other countries, advancing technological progress, providing employment, demonstrating workable techniques, and serving humanitarian needs.

A second group of basic policy considerations revolve around the questions of the extent to which the separate and collective aspects of government water programs should be paid for by the users and other beneficiaries or financed through government subsidy from general revenues, and the related question of the reliance to be placed on private initiative and private capital. Chapter II has discussed the specific problem of payment for water service. Similarly, questions of reimbursement policy must be resolved with respect to the costs of supplying agricultural water, water pollution control, hydropower and the other benefits and services provided by government water development activities.

Once some concept of national economic policy has been established and reimbursement policies agreed upon, it becomes necessary to develop techniques for the economic and financial evaluation of specific projects and programs both as worthwhile public investments and as they relate to these national policies. In the United States, sophisticated techniques have evolved, particularly since the Second World War, for making a cost-benefit analysis of Federal single-purpose and multipurpose water projects. The basic principles are that the costs of a proposed project, amortized over a stated period of years and including operation, maintenance and replacement costs as well as costs of initial construction, should not exceed the benefits generated by the project over comparable periods of time or exceed the costs of proving comparable benefits by alternative means; and that the financial operation of the project must fulfill national reimbursement policies. Benefits include those that are direct and indirect, tangible and intangible. While the process of evaluating such benefits is not, and canont be, an exact one, methods have been developed for measuring benefits assigned to the purposes served by the particular project, such as navigation, flood control, irrigation, hydropower, municipal and industrial water supply, fisheries (both sport and commercial), water quality control and recreation; and for allocating costs among these purposes.

While these techniques of cost-benefit analysis and cost allocation have been extremely useful, it is important to recognize that, if adapted to use in other countries, they cannot be relied upon as the sole test of project evaluation. They do not, for example, compare the project with opportunities for development in other areas of the country, assess foreign exchange requirements, or evaluate the relative contribution of the project to the national economic base in contrast with other expenditures of limited government funds. Even in the United States they do not tell the whole story. Congress exercises important policy judgments that are over and beyond the evaluation of the specific project proposal; furthermore, under the U.S. constitutional system, the important steps of authorization, appropriation, and execution are separately considered and acted upon.

Operation and Maintenance

In their haste to get on with water resources development projects many of the emerging countries have unduly emphasized construction but have failed to take into account the equally pressing need for long-term operation and maintenance of completed facilities, such as rural and municipal water supply installations and irrigation and drainage works. Other countries have set up adequate organizations to operate recently-completed facilities but have not provided for the relentless requirement for continuing maintenance.

Almost all of the recent loan agreements made by AID, the World Bank and the Inter-American Development Bank (IDB) require that the borrowing country take steps to assure adequate training of operating personnel and also to guarantee suitable maintenance. Emphasis should be placed on the training of semiskilled maintenance personnel as well as the more highly skilled technical people, such training to be concurrent with the construction period.

The importance of proper maintenance cannot be too forcibly expressed. This is a continuing problem not only for major water works, but also for such simple facilities as pumps, faucets, and irrigation ditches. In

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many situations the inability of individuals and local entities to repair and operate facilities is the single most limiting restraint against further development.

B. Mobilizing the Human Resources

The task of developing water resources for man's benefit and of rescuing the developing world from its hunger and disease would be hopeless but for the great advances in scientific and technical knowledge that have been made over the past few generations. Although we still have much to learn, we are no longer ignorant of the basic cause-and-effect relationships between man, air, soil, water, and the biota of a given environment. Technologically speaking, we generally know what must be done if food supply is to be increased, if disease is to be reduced, if the industrial and commercial possibilities of the water resources of a country are to be developed.

Development, however, is not a matter of technology alone. The technology of one people cannot simply be grafted onto the social structure of another with the expectation that it will thrive and produce the same benefits. Technology, in the absence of relevant data, organization, planning, institutions, human skills, available capital, and above all, the understanding and motivation of the people who are to employ it, is like a fine automobile without a driver. Technology can specify what must be done to develop the water resources of a nation. It requires the purposeful articulation of human effort, skills, and institutions to apply the technology to obtain effective results. Habits and attitudes of centuries' tenure must be adapted to new circumstances.

No attempt will be made here to catalogue all the lines of endeavor that must be pursued in order to translate the potential of technical knowledge into the reality of human benefit. A brief description of a few of these endeavors is appropriate.

Hydrologic and Related Data

It is apparent from the previous discussion in this report that effective water development cannot go forward unless basic information is at hand with respect to a wide range of hydrologic, social, and economic factors. In addition to data on water resources discussed below, it can readily be seen that realistic planning judgments on water development programs cannot be made unless adequate information is also available with respect to such socioeconomic matters as the incidence of disease, population density and projected growth, per capita income, agricultural production and potential, tax revenues, gross national product, and so forth. The compilation and analysis of data of this kind is a necessary part of every water program.

Basic hydrologic data, so essential for adequate design and planning, are obtained only by systematic observation, analysis, and interpretation of physical hydrological phenomena. The usability of such basic data is related both to spatial and temporal distributions; the reliability is related to the technical competence of the collection system. Hydrologic observations generally consist of river stage or flow records, records of well yields, flood and drought data, sediment loads, water-quality data, soil-moisture measurements, rainfall data, snow depths and accumulations, and measurements of evaporation.

Emphasis needs to be stressed on collection of data on water quality. For proper future management of highly developed river systems, the water-quality patterns, as related to flow patterns, are essential. Changes in such parameters as dissolved oxygen, nitrates and phosphates, and the pattern of dissolved oxygen sag can only be properly evaluated and dealt with if the predevelopment base is known. For example, the development of plans for reversing the eutrophication of Lake Erie is hampered by shortcomings of data on past water quality of the lake.

Attention should be given to standardization of hydrologic data, including units of measurement, and of techniques for data collection and analysis. Uniformity of methodology is also desirable to insure comparability of data, particularly for basinwide studies.

Traditionally, 20 years or more of basic data at a site has been considered reasonably adequate for design and appraisal of water resources projects. It is rare, however, for such records to exist where needed, even in developed countries. The lack of such data is especially evident in many parts of the world where societies have not emerged to a level requiring sophisticated development of their water resources. One of the special problems in these countries is the refinement of techniques for planning water projects in the absence of necessary data.

One of the priority needs for world progress in water development is the expansion of networks for the collection of basic hydrologic data and for the establishment of internationally compatible systems for the storage, retrieval and dissemination of this data. Efforts currently are underway in the United States

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to establish a facility for coordinated water resources data storage and retrieval; this system should be fashioned to include international as well as domestic data. The International Hydrological Decade can be expected to contribute to the expansion of data networks and data management. The Water for Peace conference should offer an ideal opportunity for consideration of suggestions on how best to collect, store and disseminate water data.

Information Exchange

Knowledge, be it scientific, technical, or administrative, is of no practical value unless it is in the hands of the right man at the right time for the job to be done.

While it is theoretically true that the world collectively possesses the knowledge of how to solve most of man's major water problems, this knowledge in most cases is not readily available in usuable form to those in need of it. Published information about the world's water resources and water needs is only partially adequate; and much information that has been published at one time has been lost or is buried in some government or company file. Research findings developed by one scientist often are unknown and unavailable to another working on the same problem. Training and operating manuals printed in one country are of no value to a technician from another country unfamiliar with the language.

A worldwide cooperative Water for Peace Program must be undergirded by a stepped-up systematic and rational program for information exchange. A number of techniques are effective and should be included. The familiar medium of holding conferences and seminars can be more effectively utilized through broader dissemination of the technical papers submitted and conclusions reached. Programs for regular publications exchanges and translation of selected materials should be expanded.

The nature of water and its uses is so complex and the worldwide water situations are so varied that the literature on the subject, both that which is extant and that which can be expected in the years ahead, is rapidly becoming unmanageable. This is particularly true of the literature relating to research in developed countries. Efforts are under way in the United States to establish a facility and advisory council for coordinated water resources information retrieval; this system should include categories relating to international water activities in order to assist U.S. technical assistance programs overseas.

The problem of worldwide management and exchange of water information is especially appropriate for consideration by the United Nations and the specialized agencies. The Water for Peace Conference can also serve as a useful forum for delineation of the problem and discussion of useful techniques that might be developed to make the world's reservoir of knowledge more readily available in promoting development of the water resources of the world.

Surveys and Mapping

The fundamental prerequisite for rational development of water and related land resources is the assembly of a mass of factual information and its presentation in a readily usable form. Surveys are required to ascertain general and detailed information about the *water resources*, such as river systems and ground water basins; the *land and vegetative resources*—such as soil capabilities, geologic and topographic configurations, and forest cover; and *human resources,* including population concentrations, economic activities, and water needs and uses. Such surveys may be for sections of a country or for an entire country; they may be for a river basin within one country or a river basin encompassing several countries. These surveys provide the material for formulating both master development programs and detailed plans for specific projects.

Although the information obtained from surveys can be recorded, analyzed, and presented in many ways, such as in written reports and through tables and graphs, probably the most useful technique is through maps. Maps are an invaluable tool to the modern planner; they are the medium by which a wide range of vital information can be conveyed. Unfortunately, their unique importance is not fully appreciated or widely understood. For 75 percent of the land surface of the world, there is no map on a scale as large as 1:250,000. There are, however, a number of national and international efforts going forward to extend this coverage.

A number of different kinds of maps are required by the planner that vary in scale and in the types of information shown depending on the purpose to be served. The first kind needed for development planning is a basic or reconnaissance map that shows the area's most obvious natural features, such as the location of rivers, coastlines, and harbors and the outline of wooded areas, cultivated lands, swamps, and mountainous regions; and the location of cultural features, such as cities, towns, railroads, roads, and bridges. Maps for this purpose should be on a scale

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of 1:100,000 to 1:250,000, although smaller scale maps of 1:1,000,000 are often used. If at all possible, this first basic map should be a topographic map showing the relief of land by means of contour lines.

Beyond this base map, a wide variety of larger scale, more detailed maps are particularly essential to planning the development of water and related land resources. A general inventory of physical resources is a valuable tool in areas where data needed for planning have not been gathered systematically. An example of this is the first comprehensive atlas on the Lower Mekong Basin currently being prepared by the Engineer Agency for Resources Inventories at the Army Map Service with the assistance of the Committee for the Coordination of Investigations of the Lower Mekong Basin, the Tennessee Valley Authority, and country technical experts in South Vietnam, Thailand, Laos, and Cambodia. The atlas will include maps, transparent overlays and supporting tabular data covering 41 subjects in physical, economic, and sociological fields, including water, land and mineral resources, transportation, health and educational institutions, industry and urban areas.

Medium- and large-scale topographic maps are essential, particularly in the design of multiple-purpose river basin projects and irrigation distribution systems. Maps showing the location, depth and quality of ground water resources are necessary to the management and development of surface as well as ground water supplies. Other requirements include maps showing soil classes, land use, and forest and vegetative cover. In many cases planimetric maps (not showing elevation) portraying property ownerships, although costly to produce, are indispensable, as for example, in planning and administering irrigation projects.

The worldwide need for surveys and mapping of the physical resources, as well as the human resources, is massive. Fortunately, modern technology is making rapid advances in the perfection of techniques and the development of equipment to fulfill the need much more rapidly and at a considerably lower cost than was possible under traditional methods. Prominent in the new technology are aerial photography, photointerpretation, and photogrammetry. Not only are these techniques now the most widely used method for preparing topographic maps, but they also are useful in locating potential ground water sources, in analyzing vegetation and soil resources, and in showing seasonal changes in moisture and ecological patterns. Modern electronics is providing many useful services, including the use of electronic computers for recording, analyzing and printing data and remote-sensing instruments utilizing electromagnetic and light waves.

The advent of earth satellites has opened the door to an exciting range of entirely new approaches to surveys and mapping. Satellites in the Echo series are being utilized to accomplish intercontinental geodetic ties on a worldwide basis. The Tiros, Nimbus, and Essa satellites have provided extensive information on global weather conditions. The National Aeronautics and Space Administration has made grants to the U.S. Departments of Agriculture and Interior for research into the use of multispectral remote sensing for agriculture, cartography, forestry, geography, geology, and hydrology and their adaption for use in satellites. These techniques have been used experimentally in high-flying aircraft with encouraging results to show such detail as springs, creeks, saturated boggy meadows, and second-growth ponderosa pine. Included among the types of data being acquired are radar, microwave and infrared imagery, and panchromatic, near infrared and aerial ektrachrome photography. The cooperation of NASA should be enlisted in the Water for Peace Program to study ways in which satellite technology can be made available for worldwide use in resource development.

Education and Training

Water resources development is not possible without an adequate pool of educated and trained manpower. If necessary, data can be estimated, technique can be improvised, materials can be substituted, new methods of financing can be devised, and, through the miracles of modern technology and engineering, new sources of water itself can be provided where needed; but none of this can be accomplished unless men and women possessing the requisite skills are available in appropriate numbers to perform the myriad tasks involved. Skilled manpower is the sine qua non of water progress; and education and training programs to supply the needs must accordingly be assigned a top priority in the Water for Peace Program.

The requirements for education and training in water resources development are extremely broad. Although precise classification is, of course, not possible, the necessary programs can be considered as directed toward the following six main groupings:

(1) Professionals—This category includes hydrologists, engineers, agronomists, economists, soils scientists, meteorologists, public administrators, anthropologists, and related disciplines. Formal university education is required for this group through the baccalaureate and in most cases, the graduate levels.

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(2) Subprofessionals and technicians—Large numbers of skilled specialists are required to help design, construct and inspect facilities, and then to operate and maintain them. Examples from this group include waterworks operators, maintenance crew chiefs, laboratory technicians, data network operators, draftsmen, and bookkeepers, among many others. Typically, a basic training program of 2 years beyond the secondary school level is desirable, utilizing special school, laboratory, and workshop facilities; but this can be complemented by specialized training courses from 2 weeks to 6 months, and on-the-job training programs for specific projects.

(3) Skilled workers—This class can be thought of broadly as ranging from construction equipment operators and equipment maintenance personnel to the training of farmers in techniques of operating irrigation distribution systems and in proper water-use practices. Training programs primarily involve vocational education at the secondary level, extension services in the locality, and on-the-job training.

(4) Managers and administrators—This group, although small in numbers, is particularly essential. It includes managers of water supply and irrigation systems, construction project supervisors, and program administrators at all levels of government. Practical experience is necessary, of course; so also are an awareness of the interrelated factors involved in program and project planning, organizing ability, and the capacity to make hard decisions at each stage as alternative choices are presented. Where possible, formal education in management skills is highly desirable in conjunction with other professional studies; in any event, the development of managerial and administrative talent requires a continuing program of management internships, on-the-job experience, specialized training courses of varied duration depending on the situation, familiarity with professional literature, and participation in conferences and seminars.

(5) Teachers—The requirements for teachers are as varied as the character and location of the educational and training programs themselves. General education in the subject matter and in teaching methods should be supplemented by training in specific instructional techniques related to water development and in the feedback gained from direct involvement in water projects and programs.

(6) General public—No aspect of the education and training program is more important than teaching the people to accept and sponsor both improved water use practices and developmental projects. None is likely to be more difficult. Experience proves that a procedure or practice is not altered simply because economic, social, and health benefits are self-evident in the nature and purposes of the development program. These benefits must be communicated to the people concerned in terms they can understand. One of the most effective means of doing this is through local leadership and participation of local governing and educational bodies. Properly encouraged, local leadership can be a dynamic force in the developmental process.

It has not been possible in global terms either to assess accurately the extent of the available institutional capability for training in water-related subjects at each level or to judge fully the nature and extent of programs required to provide the skilled manpower needed to carry out projected developmental programs. There are several reasons for this. Published information of a summary nature on institutional programs does not single out water as a classification; at the university level, for example, water courses are included under such more familiar headings as agriculture, engineering, sanitation, and geology. Heretofore, water has not generally been regarded as a unitary subject; the promotion of the International Hydrological Decade is designed in part to overcome this difficulty. In most countries, no systematic effort has been made to assess the needs for trained manpower at all levels to carry out projected programs to develop water resources or to assess the existing institutional capabilities to supply these needs. Nationally organized efforts along these lines have only recently been undertaken in the United States. Under the impetus of the Water Resources Research Act of 1964 efforts are underway to assess the national needs for water research and to enlarge the opportunities for training experts in water-related disciplines. The professional classification of hydrologists has only recently been introduced into the U.S. career service. The newly formed Universities Council on Water Resources is now completing the first detailed survey of the capabilities of U.S. universities for educating professionals in water skills.

Notwithstanding the lack of hard facts, it is impossible to escape the convictions that the worldwide needs for education and training programs in water-related skills at all levels far exceed the existing capabilities; that geographically considered, the capacity of local institutions is weakest in areas of greatest need; and that greatly expanded programs should be undertaken if the world is to begin to make desired progress toward solving man's water problems.

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Efforts to establish new or expanded education and training programs should be carried out through a number of institutional arrangements. The needs are particularly critical, of course, in the developing countries. President Johnson, in his message on international education and health, and elsewhere, has called for increased emphasis on educational programs. Proposed commitments for education under the Foreign Assistance Act for fiscal year 1967 amount to $179 million, an increase of more than 60 percent above commitments for fiscal 1966. Included in the program are assistance in national education planning, teacher training, installation of educational television, provision of instructional materials, strengthening of university curricula, and construction of schools. A high proportion of Peace Corps enrollees serving overseas are engaged in teaching and instruction. In view of the vital role of water use and water development in the developing world, increased attention should be given to water matters as a part of these ongoing educational programs.

Relatively few countries possess the capability to provide all of their own needs for trained manpower, and this is particularly true in the developing nations. For this reason, regional and subregional programs and institutional arrangements are highly desirable to stimulate interest, permit better utilization of limited numbers of trained personnel, and coordinate participation in education and training programs by countries outside of, as well as within, the regional or subregional areas. Proposals along these lines are discussed in greater detail in chapter VI.

In addition to the provision of initial formal training in water-related skills, attention should also be given to the need for maintenance and improvement of these skills after graduation. Refresher courses, trade publications, conferences and technical seminars are highly desirable to keep skilled personnel at all levels abreast of new and improved techniques. In this connection the professional societies can play an extremely valuable role. Their usefulness has been demonstrated, for example, in Latin America, where professional societies dating back many years have provided a professional base of support for the significant progress that has been made in health and community water supply programs.

While the case for substantial expansion of education and training efforts in water subjects is evident, there is a great need for more specific information on a continuing basis as to the extent of the need and the availability of educational and training programs to meet it. It is expected that initial country assessments can be made in preparation for the International Conference on Water for Peace. Additionally, encouragement should be given to initiation by an appropriate U.N. agency of a survey of available data concerning the existing facilities and explicit needs for expansion.

Legal and Cultural Institutions

Who owns the water in a river? Who owns the water in the ground? These questions seem of little interest to a village housewife who, perhaps, following centuries-old tradition, washes her clothes in the river and dips out enough to carry back for household use; or to an enterprising farmer who sinks a well to supply the needs of livestock, crops and home. But to the modern water planner the answers to these questions are of vital concern. The success of a new project may turn as much upon questions of water rights and water law as upon the more familiar considerations of engineering and finance. It is not unknown for reservoirs to empty, not because of drought, but because upstream users have diverted the flow of the river to their own uses; or for a well to dry up because excessive pumping of a common aquifer has lowered the water table beyond economically feasible reach.

In areas where water is plentiful, where there is more than enough to go around, and always will be for the foreseeable future, questions of property rights in the use of water are not so critical. But the places in the world where these conditions exist are not many, and their number declines each year as population, urban and industrial growth place increasing demands on the available supply. In many areas of the world, these conditions of water surplus have never existed. The inhabitants of these areas have long struggled to develop workable doctrines to accommodate the conflicting interests and to provide a sound legal base for economic progress. The lessons they have learned, and the legal institutions they have created can provide a valuable guide to other peoples faced with similar problems.

One such area is the American West. There the early settlers found that the common law doctrine of riparian rights, that permitted each owner of property bordering a watercourse to take what he needed for his reasonable use, while allowing the flow to continue otherwise undisturbed, would not serve the development needs of a more arid land. Instead, a new doctrine was evolved to govern water rights of individuals within a State based on the concept of "first in time, first in right." Called the law of prior appropriation, these rules protect the right of the first person

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to use a known quantity of water to continue to use this amount as against any subsequent upstream or downstream user.

Today a highly sophisticated legal structure exists. Typically it consists of a water code, enacted by the State legislature, that governs the acquisition and transfer of rights to the use of water and the accommodation of public and private interests; and administrative system to facilitate the measurement and recording of these rights and the management of the public interests in water; and an adjudicatory system to resolve disputes. In some cases, as knowledge of the location and behavior of water underground has advanced, the rules of prior appropriation and the administrative and adjudicatory mechanisms have been extended to ground water resources. Additionally, because of the Federal system in the United States, an extensive body of law has developed through interstate compacts, national legislation and court decisions that governs the relationships among States, between States and the Federal Government, and between individuals and government.

Another arid region of the world that long has confronted similar problems is north Africa and the Middle East. Here complex legal institutions have similarly evolved. In Egypt, for example, responsibility for irrigation waters is divided between irrigation inspectors, representing the irrigation department of the national government, and mudirs, representing the provincial government. In general, while the irrigation inspectors and their staffs are the executive agents in all matters concerning irrigation, it is for the mudirs to bring to their notice and discuss with them the needs, requests, and complaints of the public in regard to irrigation. Thus, the mudir is interested in the fair distribution of the water supply throughout the districts of his province in accordance with the needs of the crops and, in the event of a shortage or an excess of water, he invites the attention of the irrigation inspector. The mudir can only take action himself in the case of pressing danger from the breaching of banks or the failure of works and only when a representative of the Irrigation Department is not present. As for the irrigation inspector, his duty is to meet the wishes of the mudir with regard to a fair distribution of the water supply, and he alone is in technical control of that distribution. He should provide all information desired by the mudir, notify him of rotational supply measures, and keep him informed of all changes and improvements proposed in the irrigation and drainage arrangements of the province. If at any time there is disagreement between the two, they can refer the matter to their respective ministries.

Parallel with the development of legal institutions relating to the distribution and use of water are a host of legal arrangements dealing with construction, operation and maintenance of water projects and the important matter of providing revenues to defray the costs of these services. In the United States, heavy reliance is placed on local governmental entities, such as city water supply departments, irrigation districts, levee districts, and the like. Financing comes from charges for water, revenue bonds, and the taxing power. In instances where sufficient revenues are attainable, private enterprise will provide these water services. The Federal Government plays a significant role in the construction, operation and maintenance of water projects, and many of the costs are reimbursed by private users. State governments are becoming involved on an increasing scale; preeminent among the State programs is the multibillion-dollar water project being undertaken by the State of California. Governmental entities often invoke the constitutional power of eminent domain to acquire property rights essential to a project, and a similar power is available in certain situations to private interests.

Other countries have responded to the need for organizational and financial arrangements in a variety of ways. In Italy, for example, the Government, in order to insure a better use of water, may compel some or all of the users to form a consortium in which the State is represented, to carry out reclamation and hydraulic utilization projects. In Jordan, two-thirds of the owners of irrigated lands within an irrigation area may approve the construction of irrigation works, the costs of which shall be borne by all the owners in proportion to their ownerships of irrigated land. In Tunisia, associations may be formed for the construction and maintenance of waterworks, subject to the approval of the Prime Minister following a public hearing; construction is carried out under the technical direction of the Director-General of Public Works, who also may make loans or partial or total advances of funds to the association which are repayable within not more than 25 years under conditions set by him.

In addition to the legal institutions relating to water rights and to project implementation, a third area of concern deals with the public authorities regulating the management and use of water resources. Difficult problems of this kind are particularly presented in the control of pollution and of floods. To what extent, if any, does an individual, an industry, or a city have the "right" to pollute public waters? What mecha-

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nisms are available to public agencies to regulate or prevent pollution, having in mind the economic investment in established methods of operation? Questions such as these are being explored with increasing urgency in the industrialized countries as the cumulative devastation of pollution practices continues to accelerate. The enactment of the Water Quality Act of 1965, and the pending Clean Rivers Restoration Act, are recent indications of Presidential and congressional concern with these problems.

In the industrial Ruhr area of Germany, a highly effective system has been evolved that permits multiple-purpose management for waste-carriage, water supply, and recreation of a vital water resource. The system is administered principally by seven large water resources cooperative associations called Genossenschaften, with origins dating back to 1904. Membership, consisting principally of municipal and rural administrative districts, coal mines and industrial enterprises, is compulsory; and the associations have the power to assess costs against their members based, among other factors, on the quantity and quality of waste water discharged.

The reduction of flood damage, usually through the construction of storage, channelization and containment works, has long been recognized as a public concern. In recent years, however, increasing attention has been given, for example, to an intriguing aspect of these programs, namely, that the very success of a project in subduing floods of more routine dimension often only leads to an escalation in the damage from more severe floods, because extensive new investment is attracted to the flood zone. This has led to investigation of the regulatory mechanism of flood-plain zoning, as one possible means of attaining a permanent end to the public expense.

The importance of legal institutions in water development has too often been overlooked. The development of water law must parallel and in many cases precede that of water works. The advanced nations can benefit from sharing their knowledge and experience as they seek to fashion new instruments for dealing with new problems; they also can contribute valuable assistance to the developing countries in shaping legal institutions to meet old as well as new necessities. The capabilities for studying legal problems and exchanging information should be strengthened within the United States, as well as in the world community. U.N. development programs should be encouraged to provide more advice and assistance on water law problems and on the organization and functioning of institutions needed for water resource development.

A word of caution should be stated, however, in considering the facility by which the experience of one country can be translated into institutional arrangements in another. Legal relationships are an integral part of the cultural fabric of any people. Cultural institutions, like legal ones, usually evolve slowly. They are shaped by religion, by history, by language and by the natural environment. Shared convictions about the relationships among individuals and between the individual and the group; assumptions regarding initiative and responsibility; concepts of justice; attitudes of fatalism or optimism toward the environment; policies regarding payment for water; and many other cultural precepts will determine whether any given institutional arrangement will succeed or fail. The study of institutional transfer from one culture to another is not only fascinating of itself, but it is an important requirement for facilitating the strengthening of institutional support for water development.

Government Organizations

Water resources development is not possible without competent and complementary governmental organizations at the national level, at the local level, and in many cases, at the state or provincial level. Where appropriate organizations do not exist, they have to be established as an essential step to planning, constructing, operating and financing water programs; where present agencies are inadequate to the task, action is required to invest them with appropriate authority, to clarify their relationships with other agencies working in water-related fields, and to provide the necessary budgetary support to enable them to function in a continuously effective manner. Very often the enactment of carefully drafted national legislation is a first requisite to these steps.

Many references to the role of governmental entities in water development are made throughout this report. However, two aspects of governmental organizations deserve special comment here. The first is the imperative need for clarification of the respective roles of each agency and for establishment of an effective machinery for coordination Water, the universal resource, presents many faces to the users, and traditionally a separate agency has developed to serve each particular purpose.

This is particularly true at the national level of government. Water for living is typically the concern of the ministry of health, and may also involve finance, urban affairs, rural affairs, and public works.

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In most cases the responsibility for water for agriculture is assigned to a ministry of agriculture (in the U.S. Government, the responsibility for major irrigation development in the West is assigned to the Bureau of Reclamation of the Department of the Interior); fisheries development, however, is usually given to another agency. The functions of water transportation and hydropower may have their own separate sponsors, or be combined with other functions; as may the responsibilities for river basin development, upstream watershed management including forestry, flood control, ground water development, pollution control, desalination, and meteorology. The functions of data collection, resources surveys, and mapping may be fragmented, separated, combined with other responsibilities, or ignored. Education and training usually is the responsibility of a ministry of education.

There is no magic or universal formula for organizing around these responsibilities. The important questions are whether the existing system works and whether it can be improved. Bureaucratic rivalries should be held to a minimum, and effective coordinating mechanisms should be established. The United States has moved significantly to improve coordination of its diverse programs through enactment of the Water Resources Planning Act of 1965, which will facilitate coordination of Federal programs at the national level and coordination of Federal, State, and local planning efforts within river basins.

The second important aspect of government organization is the need to provide continuity in staffing at all levels. Many experts working in international technical assistance report the frustrating experience of having carefully trained a competent man to understand and perform a key role in a government agency only to see him leave his post because of a change in the political composition of the government or because a better paying job was available in another field. Personnel stability can be provided through such institutions as merit systems, better pay, professional recognition and prestige, and the many other arrangements provided by enlightened concepts of public administration. Often, attention paid to these arrangements will contribute more to the permanent success of water development than any other aspect of the total program.

Research

Even with the best possible arrangements for all aspects of collection, dissemination and application of present knowledge on water resources development and management, there is still a great need to learn more. Research is required in many fields of water knowledge: water chemistry and biota; the interplay of soil moisture, fertilizers, pest and weed control, seed varieties, and cultivation practices on crop yields in different areas; sewage disposal and treatment, dissipation of heat and industrial wastes, and other aspects of pollution control; reduction in water losses by evaporation and seepage; soil conservation and erosion control; desalting; and weather modification—among others.

A great amount of such research is presently being carried out in the United States and more is planned. The President recently released a lengthy report outlining a 10-year program of water research. Similar research is being conducted in many other countries under national and international sponsorship. The fruits of this research can and should be made available to all interested nations under the Water for Peace Program. For example, valuable information and experience are being obtained through U.S. research on desalting technology, on pollution control, on the use of nuclear energy for water development purposes, and on the employment of satellites for resource surveys and mapping—all of which can serve as the basis for developing new and useful techniques applicable to overseas efforts.

In addition to these ongoing and projected research efforts, there are certain kinds of specific problems the investigation of which is appropriate for inclusion directly as part of the U.S. program. The studies proposed by the U.S. National Committee under the International Hydrological Decade will contribute to a better understanding in worldwide terms of continental water balances, the relationships between water and land, and the behavior of global hydrologic systems. Additionally, a limited program of applied research and studies, including testing, is required that is directed to the solution of specific problems in water resources development particularly characteristic of the less developed countries. Examples of this kind include the development of simplified technology; solution of specific difficulties arising from the use of equipment, such as corrosion; and evaporation control and soil moisture conservation under unusual local conditions; together with studies of administrative, financial, legal, cultural and institutional problems discussed in other sections of this report.

Most of the world's research effort and applied technology in water matters has been devoted by the industrial nations to the temperate areas of the world. As a consequence, relatively little is known about the behavior of water in tropical climates. The tropical

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belt contains areas of the world's greatest rainfall and worst floods. It also has some of the world's largest deserts, and its worst droughts and famines. The very climatic conditions which favor abundant rainfall and lush vegetation, also encourage the rapid growth and spread of disease-bearing organisms. While this belt contains less than one-half the land surface of the world, it contains most of the population of the developing nations of the free world. Certainly the tropical areas present the greatest challenge to the Water for Peace Program to provide, through the application of modern scientific-research and technology-development techniques, the new knowledge necessary to serve mankind's greatest needs for water.

For these reasons, the Water for Peace Program should encourage the establishment of scientific programs and research capabilities to investigate the special problems presented by this zone. One such current effort is the research program in Arid Zone Hydrology carried out through UNESCO sponsorship of such activities as research projects, conferences and seminars, and publication of monographs and reports. Support for this and similar programs should be coupled with the establishment of several regional or subregional research centers located in representative climatic and ecological environments. Proposals for such centers are discussed further in chapter VI.

U.S.-sponsored research might be conducted in the United States or abroad. It could be carried on by U.S. firms, universities, foundations, Federal or State agencies, or research institutes. Financing might come in part from foreign currency funds available to the U.S. Government, if existing administrative limitations are liberalized or removed that restrict the expenditure of these funds to research applicable to solution of problems in the United States. As tropical zone research programs and centers are developed, special arrangements within the United States should be worked out for mutual cooperation and support. Cooperative research projects with governments and institutions of other countries should also prove fruitful.

C. Allocating Material and Financial Resources

Materials and Equipment

Planning for the construction and operation of water projects, from the installation of a simple pipe from a nearby spring to the construction of an extensive urban water supply system or huge multiple-purpose river basin project, presents many difficult decisions with regard to the selection and use of materials and equipment, particularly for projects in the developing countries. The first impulse of a U.S. design engineer, for example, might be to approach the problem with the same implicit or explicit assumptions as to the availability of materials, use of equipment and cost that he would use in undertaking a similar assignment in the United States. Practical experience gained at each step of the process immediately or ultimately reveals, however, that each of these many assumptions has to be reexamined and readapted to local conditions.

A host of interrelated and often unique questions needs to be asked and answered if the project is to serve its intended purpose successfully. What natural resources will be used, such as soil, sand, gravel, stone, and water? Where and in what quantities can they be found? What are their chemical and physical properties? What construction equipment can be supplied locally and what has to be imported? Where low-cost labor is available in quantity, what labor-intensive construction techniques can be employed? What building materials and machinery will be utilized, in what sizes, shapes, and complexity? Can they be manufactured locally or will they have to be imported? What kinds and numbers of skilled individuals are required? Is the necessary manpower available, or will it have to be trained for the job? What are the energy requirements and how will they be met? What are the needs for operation and maintenance, and what arrangements in the way of institutions, skilled workers, and facilities should be made to provide these vital services? Lastly, how will project construction, operation and maintenance be financed? What revenue sources are available locally, and how can foreign exchange costs be kept to a minimum?

The key to success in resolving these questions can be summarized as systems analysis combined with adaptation and innovation. Application of this approach in technical assistance programs is an art in itself to which the Water for Peace Program should give separate attention. The United Nations and the specialized agencies have sponsored studies into the standardization and use of materials and equipment. Consulting engineering firms that specialize in technical assistance contracts have developed considerable expertise in this field, as have oil companies and other industrial concerns operating in far-flung corners of the world. Studies should be undertaken looking to the design and manufacture of equipment particularly adapted to the institutional situations existing in the developing world. Valuable ideas might be obtained

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by looking backward in time, technologically speaking, into U.S. experience to rediscover durable devices that have now been replaced by more sophisticated equipment. Emphasis should be placed on the utilization of supplies and equipment which can be produced locally. Lastly, the exchange and enhancement of knowledge should be encouraged through conferences, seminars, and publications.

Country and regional planning for water resources development should also look beyond the single confines of water alone and consider it in relation to the integrated development of the total resource complex. All natural resources are complementary and, in many cases, interchangeable. The Tennessee Valley is a world-famous example of the integrated development of water, land and minerals to serve the multifold demands of regional progress. There, among other accomplishments, as is possible in many areas of the world, hydropower supports agriculture by providing energy for the production of fertilizer as well as for the electrification of the farm. Other combinations of development are also possible. In a coastal region short of water but newly rich in oil, for example, an industrial complex might be possible involving oil-fired steam generating plants and catalytic hydrogen plants to produce fresh water and fixed nitrogen fertilizers for the agriculture of arable lands, hydrocarbon and nitrogen intermediates for the manufacture of synthetic fibers for clothing, and power for electrifying the countryside. An arid area having access to saline water, no known fossil fuel reserves but large deposits of potash, phosphates and metals, might support a major mining and industrial economy with a triple-purpose nuclear-powered complex to produce electric power, residual steam and residual power for water desalination, and fixed nitrogen for agricultural chemicals.

Financing

Any expansion of worldwide water development under the stimulus of the Water for Peace Program obviously will require increased levels of financing, derived primarily from local sources, but supplemented from international sources. The amounts of this additional financing cannot be determined at this time, however, on the basis of available information and data. A number of steps must be taken before a meaningful assessment of financial needs, policies, and resources can be made.

The first essential step is for each nation or region desiring to expand its water development activity to undertake a program for the systematic analysis of its total financial requirements over selected periods of time. This systematic assessment will involve an inventory of water needs and opportunities for development; the formulation of intermediate and long-range goals; judgments as to the requirements for information, data, skilled manpower, government organizations, legal and cultural institutions, and materials and equipment, and the programs to provide any of these where they are lacking; and only then, a composite analysis of what the approximate financial requirements will be for each phase of the total program over short, intermediate, and longer intervals. Many, if not most, countries lack the capability for making systematic reviews of this kind as an integral part of their planning process. Consequently, the provision of expert assistance in this work should be a first order of business under the Water for Peace Program.

Of prime concern in financial planning will be studies looking to the attainment of revenues from local sources. These include an exploration of institutional concepts relating to the ability of consumers to pay for water either directly through the mechanism of water charges or through local taxation. In the United States a prime source of local capital has been from the sale of revenue bonds issued by local governmental entities and repaid with interest over a period of time from water collections as well as tax revenues. Opportunities for transferring this or similar financing institutions to other countries should be explored. Arrangements for revolving credit plans should be investigated. Reimbursement policies, and the extent to which aspects of water development will be subsidized by national and local governments and from other revenue sources, will have to be clarified and agreed upon.

Finally, after country and regional planning has advanced to the stage where solid information is available about the place of water development within total economic development, the costs of all phases of the water program, and the local revenue sources obtainable, consideration will have to be given to the extent to which financial assistance, primarily for foreign exchange costs, will be required from the international community.

It has not been possible at this time to make a realistic assessment of the availability of international capital in relationship to the worldwide need. There are several reasons for this difficulty. One already mentioned is the deficiency in realistic planning at the national and regional levels as to the need for such financial support. In this connection, specialists in international financing activities, including experts from AID, report that perhaps the most critical shortage is the lack of well-planned projects which meet lending standards, and

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that this in turn derives from a shortage of trained personnel to carry out the complex planning functions. The President of the World Bank, George D. Woods, described this problem in an address to ECOSOC last year:

*One of our major operating problems has been to find projects of high economic priority that have been well conceived and well-engineered * * *. Neither general programs nor even generous supplies of capital will accomplish much until the right technology, competent management and manpower with a proper blend of skills are brought together and focused effectively on well-conceived projects.*

A second difficulty arises from an incomplete understanding of the limitations on the capacity of any given nation to absorb additional amounts of international capital. This requires a highly sophisticated analysis of interrelated economic, institutional and fiscal relationships involving all phases of national life, and not just water development alone.

A third problem is that the readily available reports of bilateral and international lending activities do not easily lend themselves to segregating out water matters from other developmental assistance.

As a result, only generalized observations are possible. Financial assistance for single-purpose and multiple-purpose hydropower projects has been given heavy emphasis, principally because these projects have dramatic political appeal, because they contribute to the energy infrastructure of a country, and because repayment can be financed from the sale of electricity. Agriculture has received considerable attention, although it often is difficult to separate out the water component from the other aspects of agricultural development.

The best statistics and the least disagreement exist with respect to data on projects classified as community water supply projects, a term which includes rural as well as urban supply systems.

Table 3 summarizes the information available with respect to the local and international financing of urban and rural water supply projects in middle and South America. This table shows a current annual rate of international funding of approximately $80 million a year; this is joined by local financing of approximately $100 million a year for a total effort of about $180 million a year. Analysis of the available reports of the lending activities of the World Bank, other international lending institutions, and bilateral programs of the United States, indicates that the rate of international financing of community water supply projects worldwide is in excess of $120 million per year.

Desalting technology holds the promise of contributing to the solution of water supply problems heretofore regarded as insurmountable. Although at the present time and under the present state of the art, however, the unit cost of desalted water is considerably higher at most locations than the cost of providing additional water supplies through other means, planning studies show that unit water costs can be reduced considerably by large-scale, dual-purpose desalting plants which also produce large quantities of electrical energy. Under appropriate policies, in selected cases, subsidy of the cost of such large-scale projects is merited to advance the improvement of this technology and to promote international cooperation, particularly in areas where conflict over existing international water sources has contributed to international friction. For these reasons, further development of desalting technology should be encouraged on a case-by-case basis, and special financial arrangements may be required for this purpose.

In conclusion, it can be predicted that additional levels of international financing of foreign exchange costs will be required to sustain increased water development to serve mankind's needs. While it is not possible to say what these levels will be or what arrangements might be needed to attain them, the subject should be kept under constant surveillance as an important aspect of the Water for Peace Program. Where needs are clearly demonstrable, discussions of the problem should be pursued through established international channels and new financial arrangements implemented if necessary.

D. Blueprint for Action

Goals

Setting goals performs two absolutely essential services to any program: it provides direction and it furnishes a yardstick with which to measure progress. Without either, the effort expended is likely not only to be wasted, it may actually be self-defeating.

Goals are, therefore, a necessary part of every enterprise at every level, and in the normal hierarchical arrangement of progressive effort the goals at one level depend upon realizing the goals at the level immediately below it. Goals in one line of effort also affect programs in other lines. The setting of goals therefore becomes an important early task to be accomplished under the Water for Peace Program.

Goals relating to water development may be stated in terms of the *end uses for water,* such as community

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water supply and health, food production, transportation, hydropower, and recreation; in terms of the *development and control of the water resources,* such as multiple-purpose river basin projects, upstream watershed management, flood control, and pollution control; and in terms of the *supporting programs involving knowledge and people,* such as establishment of basic data networks, training of professionals and technicians, enactment of water legislation, establishment of appropriate national and local organizations, and research programs.

The formulation and revision of goals, whether intermediate or long-range, primary or supporting, is necessarily a continuing process. Knowledge and experience gained with one stage is relied upon to refine judgments for subsequent stages. Although goal-formulation in human endeavors can never be an exact process, and need not be, a certain amount of care should be exercised in the statement of objectives and in the recording of success or failure, for reports of progress toward the attainment of stated ends can frequently be misleading. A common error is to focus solely on progress in the installation of facilities, while ignoring the question of whether, over a period of time, the facilities are in fact put to the use for which they were intended. In the early years of the post-World War II technical assistance programs, for example, a number of dedicated efforts were made to install pumps in rural areas for community water supply. Today many of these stand rusting and unused, as silent monuments to man's folly, because the local populace did not understand their proper use, and because responsibility and supplies for their maintenance were not provided. Another frequent mistake is the failure to relate the measure of activity to the ultimate end-benefit desired. In the case of irrigated agriculture, for example, the desired result is the production of increased quantities of consumable food; but imposing government reports showing the number of miles of distribution canals constructed or the number of additional acres of land irrigated are not necessarily relevant indicators of progress toward this end if the farmers are not trained in proper irrigation practices, if operation and maintenance of the facilities is not provided on a continuing basis, and if the other elements, such as seed and fertilizer, that are necessary in combination with water to produce increased yield, are lacking.

A final essential consideration is that the goals established should be chosen by those responsible for carrying out the implementing programs. The success of the countries in middle and South America in moving toward attainment of the 10-year goals in urban and rural water supply set forth in the Charter of Punta del Este, is attributable in important part to the fact that responsible ministers representing the American States joined in setting the common goals.

Planning, Stage Development, and Self-Help

The discussion in this chapter demonstrates that a successful response to the needs and opportunities for water resource development requires the right combination of a variety of factors mutually balanced to attain selected progress over stated periods of time. Intelligent planning is the process that marshals the facts, discloses deficiencies, evaluates alternatives, facilitates decisions, and lays out the course of action to be followed. Plans unrealistically drawn and improperly executed are worse than having no plan at all, and a common failing is to assume that the mere existence of a plan is evidence of adequate planning. There is a difference, as every nation, including the United States, has discovered, not once, but many times. In a period when the lives of millions of people may depend on right and timely action to provide critically needed supplies of water, the function of planning assumes an importance out of all proportion to the number and placement of those engaged in it. Its presence spells the difference between success and failure, progress and frustration, order and chaos.

The different kinds of planning involved can be grouped into the general categories of national planning, basic or regional planning, and project planning, and each is discussed briefly below. All of these planning operations involve common fundamental principles; two of these are worthy of special emphasis. The first is the simple but often obscured fact that total progress cannot be made in one grand sweep, but can only be made one careful step at a time. This is the principle of stage development, which is stressed throughout this report. The important thing is that each step is directed so that more fruitful progress will follow.

The second basic principle is that nations and regions of the world which have water problems and desire to respond to them by promoting water development, must undertake this responsibility themselves. Through the Water for Peace Program the world community can exchange knowledge and experience, offer encouragement, supply technology, and provide technical and financial assistance, but one nation or region cannot do the job for any other. This principle of self-help is fundamental to the program.

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Adequate planning at the national level is essential to provide over-all direction to the total program, and to each phase within it, and to relate water development to other national needs. To carry out effective national planning, countries should establish broad water-use planning activities within the framework of their national planning agencies, combine water-use planning with sectoral planning, coordinate the various activities of the central, state and local governments and the private sector in the water-use field, and improve the techniques for water-use planning and project evaluation. Water-use planning should include the necessary sectoral studies and preinvestment surveys to establish priorities and determine benefits of specific projects. In many cases financing for the studies and for the ultimate projects already exists if the projects can be determined to be of high priority.

Careful planning is necessary within each river basin or region to provide that the development of all water and related resources therein proceeds in reasonably harmonious relationship among themselves and with all other developmental activities.

Such planning is especially important to the modern, multipurpose, whole-basin concept of water resource development. Planning goes beyond the needs of the engineer to help assure that the best water service can be provided for the greatest number of people with the minimum of hardship to those who inevitably suffer from the changes required.

Proper basin and regional planning facilitates viewing a project for one purpose, such as irrigation, in the light of future needs for water for municipalities, industrial development and other purposes in the same area. It will provide basic economic studies for use in evaluating all individual project proposals, make systems analyses of the entire hydrologic regimen of the basin, indicate resource relationships that must be considered, and suggest priorities for each phase of development.

The planning process for individual projects and programs, in addition to relating the project to national and basin or regional plans, must include all of the factors necessary for the total project operation to serve its intended function both initially and over its designed life. The project plan should take into consideration its impact on other programs; should demonstrate engineering feasibility, economic soundness, financial support and operational success; and should be compatible with later phases of development.

One of the most useful services the United States and other developed nations and the United Nations agencies can provide developing countries is aid in planning, drawing on their own longer experience. Yet it is clear that the modern nations also have much to learn. The nations participating in the Water for Peace Program will all benefit if early attention is focused on methods and scope of water resources development planning.

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IV. RIVERS FOR PEACE

The integral nature of river valleys and the interdependence of those who live in them have led to rivalries, irritations and armed warfare that have taxed the efforts of peacemakers for thousands of years. Water, fully as much as land, has been fought over, disputed, and otherwise contested by rival claimants at every level from the individual to the nation. However, where a supervening authority exists over the disputed region, the differences can be composed by mutual consent, if possible, or by law if necessary. But since integrated authority ends at the level of the nation-state, rivers which are shared by two or more nations present a problem of great magnitude to the peaceful relationships of the nations who seek the benefits of the waters they carry.

International rivers do not merely bring problems. They provide matchless opportunities for cooperation between people and nations for the peaceful development of their potentials. The enormous advances in science and engineering over the past half century have accentuated these opportunities by making possible many essential features of cooperative development that formerly could not have been accomplished at all. To an ever-increasing degree, the management of international rivers is becoming not merely a matter of distributing existing benefits, but of increasing them greatly through cooperative action. The possibility of developing the water resources of the international river for the benefit of all parties can be highly instrumental in settling age-old disputes over water rights. Of vastly more importance, however, is the stimulus that a successful venture of this nature can give to the solution of other issues which trouble the relations of neighboring countries. Every such agreement is a victory of fairness over force, or friendship over enmity, and of hope over despair. Because the river is such an elemental part of the life of the undeveloped country, its cooperative development for the mutual benefit of riparian neighbors can become the foundation on which other structures aimed at promoting peace and harmony between them can be built. The United States has used its good offices for this purpose in three outstanding cases in recent years—the Indus, the Mekong, and the Jordan. International cooperation has led to significant progress in two of the three situations. They should be referenced for lessons that can be usefully applied in future cases.*

Much of the land surface of the world is included in such international river basins. The 1958 United Nations Report on Integrated River Basin Development (E/3066) lists 129 international basins, 55 covering areas greater than 100,000 square kilometers, and 74 smaller ones.

These international basins offer a unique challenge to the Water for Peace Program. Not only will physical development redound to the benefit of the peoples in the riparian countries through the provision of more available water supplies for human use, the increase of agricultural production and the establishment of a resource infrastructure to support economic progress, but multination participation in the common cause for common benefit will afford new and permanent occasions for peaceful cooperation.

Many successful international efforts looking to the regulation and development of international rivers have been undertaken in the past and are now underway. In addition to the Indus and Mekong Basins, multilateral and bilateral treaties relating generally to contiguous and successive rivers in the territories of the signatories, or to one or more specific rivers, have created legal rights and obligations with respect to many other important international river systems. To name only a few: In North America, all boundary waters between the United States and Mexico, and between the United States and Canada; in Europe, the Danube, Rhine, Moselle, and Oder; in Africa, the Nile; in the Near East, the Tigris-Euphrates; in South America, the Uruguay. Several conventions relate to international uses of water in a more general context: The 1921 (Barcelona) General Convention Regulating Navigable Waterways of International Concern, and the 1923 (Geneva) General Convention

*See app. III for case studies of these three projects.

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Relating to the Development of Hydraulic Power Affecting More Than One State.

Under the sponsorship of the United Nations and the specialized agencies a number of programs to stimulate cooperative interest in international river basins are going forward. In Africa the Senegal River Basin is being developed through an interstate committee of the four riparian countries, Guinea, Mali, Mauritania and Senegal. The nine riparian countries of the Niger River Basin have started cooperative efforts with U.N. help. Preparations are being made for multipurpose development of the Gambia River, which originates in Guinea and flows through Senegal and Gambia. Activities in the nature of basin or hydrometeorological surveys are directed toward the Mono River and Lake Chad Basin, the Logone River, and for the catchment basins of Lakes Victoria, Kioga, and Albert.

In Latin America attention is being focused on the Rio de la Plata system, which comprises an enormous drainage basin covering the whole of Paraguay, southeastern Bolivia, most of Uruguay and large portions of Brazil and Argentina. In Asia and the Far East, ECAFE has completed a compendium of 12 major international rivers in the region.

A further indication of the accelerating interest of the United Nations in the development of these uniquely international resources is the proposal of the Secretary-General to conduct a survey of the potential for development in international rivers. It is contemplated that the survey will assemble existing information and concentrate on the possibilities of the development of international river basins for flood control, navigation, hydropower, irrigation, municipal and industrial water supply, and recreation and tourism. This survey is one of nine surveys in natural resource development proposed as part of a 5-year program. It is described in the Secretary-General's report on "Development of Nonagricultural Resources" (E/4132) submitted in January 1966, to the United Nations Economic and Social Council. The report expresses the opinion of the Secretary-General that if and when budgetary and/or extrabudgetary resources can be mobilized for its implementation, such a program can make an important contribution in the second half of the United Nations Development Decade to the promotion of nonagricultural resources for strengthening the economic basis of the developing countries.

The development of international river systems is a particularly appropriate objective for the Water for Peace Program. Many of the underdeveloped nations are reaching the point where a common effort to develop their international rivers could provide the power, irrigation, navigation, and other benefits critically needed for their social and economic progress. In many of these cases, the riparian states have not yet reached the stage of development where their demands on the river waters have created serious disputes with their neighbors. But as growth progresses, such disputes will inevitably arise. Therefore, both from the standpoint of encouraging the development of water resources for peaceful growth and avoiding potential acrimony, it is important that measures be undertaken now or soon to organize the institutions, draw the plans, and commence the construction necessary to develop the resources of these systems.

The large number of river systems available for development and the high cost of work of this kind require that initial attention be focused on a few selected systems. In this connection, the Committee on Natural Resources Conservation and Development of the National Citizens' Commission recommended to the White House Conference on International Cooperation that one or more rivers should be chosen in each region of the world for study, planning, and development as examples in international cooperation.

It is not for the United States to choose such examples. This is, of course, the privilege of the nations in the several regions of the world themselves. They should have the able and impartial advice of the U.N. and its respective agencies for this purpose. The proposal of the United Nations Secretary-General for a study of the opportunities for development of international rivers is a welcome initiative to which we believe the United States should give an encouraging response.

Although adequate details of the proposed study are not available and should be provided, it is clear that the United Nations can perform a useful role in stimulating preliminary discussion, assembling and publishing available information, and indicating useful steps that should be taken to obtain more detailed data, undertake planning, and establish mechanisms for multilateral cooperation. Concurrently, other avenues for stimulating local and regional initiative should be pursued. For example, the preparations for and discussions at the Water for Peace Conference might provide a basis for indicating river systems to which early attention should be given.

Finally, it is both necessary and appropriate that the United States stand ready with the U.N. and the specialized agencies and other developed nations to help in the development of the rivers selected.

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V. EXISTING BILATERAL AND MULTILATERAL PROGRAMS

Although international cooperation in mutual development activities is probably as old as the establishment of nation-states, the post-World War II period has seen an unprecedented proliferation in the number and extent of private and public cooperative institutions and programs. The creation of the United Nations in 1945 has contributed in countless ways to this new dimension in international cooperation, as has the United States foreign assistance program beginning with the Marshall plan in 1946.

The Water for Peace Program seeks to infuse increased emphasis on water matters within these programs, to establish improved mechanisms of cooperation, and to facilitate a more systematic and rational approach to worldwide water resources development. To do this, the program must, if it is to be successful, be built upon the experience, skills, and knowledge of the agencies already involved in international development activities. The program also must keep water resources development in its proper perspective as but one facet of total socioeconomic development generally. There are few development goals that do not at some point become a function of, or impinge upon, the existence, creation and management of water resources. Consequently, it is hardly surprising to find that many agencies concerned with social and economic development have devoted a significant share of their efforts and resources to water development.

In this chapter the principal entities engaged in development assistance and scientific and technical cooperation are described briefly and their water resources activities noted.

A. United States Development Assistance

The United States is the principal contributor to all multigovernmental development programs described in later sections of this chapter. This section deals with U.S. assistance that is not commingled with that of other donors.

United States bilateral aid is by far the largest single source of foreign assistance. From the inception of the Marshall plan through fiscal year 1965 direct dollar assistance extended through the Agency for International Development (AID) and its predecessor agencies amounts to over $40 billion. This figure does not include certain sums made available under special arrangements or separately administered. This category includes some $4.9 billion in Public Law 480 local currency used for development purposes, and $525 million Social Progress Trust Fund administered by the Inter-American Development Bank, the development loan programs of the Export-Import Bank of Washington, the very large foreign exchange assistance by means of agricultural commodities provided under Public Law 480, the activities of the Peace Corps, etc. In recent years, total U.S. foreign assistance has averaged over $3.5 billion per year.

The AID Programs

Assistance extended by AID is developed under the concept of integrated country programing. This concept requires that no element of AID assistance be considered without reference to the total use of the internal and external resources available to the country. Thus, AID programing takes into account not only what the country is doing with the resources which it controls but also the foreign assistance being made available by multilateral and other bilateral donors. For AID the decision to finance a water development program must be evaluated not only in relation to other water development activity but in relation to the country development program as a whole.

AID assistance falls into three broad categories each of which is significant to water resources development. These categories are (1) technical assistance, (2) program assistance, and (3) capital assistance.

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Throughout this report the discrepancy between existing knowledge and current practices has been stressed. The objective of *technical assistance* is to help close this gap through the transmission of knowledge and skills from the more to the less developed countries. Frequently, the transfer of knowledge, plus the grant of relatively small amounts of essential equipment is sufficient to release a flood of development activity. In Yemen, for example, an AID project which offered technical assistance plus some "bargain basement" equipment including surplus World War II storage tanks, has produced a water works system in Taiz which has affected the entire country.

The city of Taiz, Yemen had changed little in the past 1,000 years. This was also true of the city's water supply which provided less than 4 gallons of water per capita per day to the population of around 20,000. This water was collected from springs in the surrounding mountains and transported to the city through open masonry channels. It was often polluted en route. As a result of an AID program a new water supply system is now in operation providing 40 gallons per capita per day of safe, clear water and a new Department of Water Supply and Sanitation, although still under the direct supervision of U.S. technicians, is growing toward self sufficiency. This new water supply system was enthusiastically received by the people of Taiz and the Government of Yemen as an expression of interest and friendship by the United States. At the instigation of the Government of Yemen it was designated as the "John F. Kennedy Memorial Water Supply."

A newspaper account of the project notes:

"The project has had two important side effects. As the waterworks was being built, a Yemeni Department of Public Water Supply and Sanitation was organized which will eventually take over the program. Prior to the Kennedy Waterworks, no one had ever seen the need for a sanitation department."

"Setting up the sanitation department has involved training more than 250 Yemenis in everything from accounting to well drilling. Twelve were sent to the United States for training."

"The second result was to create a demand for clean water systems throughout the country. The bigger cities of Sanaa and Hodeidah have put in bids for similar projects."—(Washington Post, Monday, Mar. 21, 1966.)

Program assistance is the provision of generalized balance of payments support through AID financing of commodity imports, usually for resale through normal distribution channels within the recipient country.

While this type of assistance cannot be readily identified with specific water resources development activities, its impact is none the less real. AID financed imports of cement, steel, pipe, etc., provide an important source of operation and maintenance supplies for existing water works and the local currency which accrues to the recipient government from such assistance permits it to finance public works, including for example, community water supply undertakings.

In recent years the greater part of AID funds have been used for *capital assistance,* i.e., financing, usually by loans, to establish or expand physical facilities and financial institutions (including feasibility studies) that contribute to basic economic development. A wide variety of capital assistance water development projects have been financed by AID of which the Shihmen project in Taiwan provides an interesting illustration of multipurpose water development.

The Shihmen Multipurpose Dam project was the first large-scale water resources development undertaken by the Republic of China as a part of the overall development program to make Taiwan economically self-supporting. This project encompasses community water supply, irrigation, power, and flood control objectives.

The main features of the project are a reservoir with a storage capacity of 316 million cubic meters, a main dam with a height of 436 feet, a powerplant with two 45,000-kilowatt generating units; the new Shihmen Canal System, serving 23,000 hectares of high land which formerly were dry farmed; and a public water supply system and treatment plant of 30,000 cubic meters per day for domestic and industrial uses of 148,000 urban people now living in the region for whom no proper water supply was available. The total irrigable land to be benefited by this project is 58,000 hectares. The water supply system can ultimately be expanded to 86,000 cubic meters per day to meet the demand for a population of 340,000 in the next decade.

The reservoir was completed in May 1963, and was put to a severe test in September 1963 by Typhoon Gloria, one of the worst in the history of the island, with 66 inches of rainfall in 69 hours. The reservoir was utilized to its maximum, preventing any serious damage downstream. Power generation began in January 1964, the irrigation system in mid-April and the municipal waterworks system in June 1964. The reservoir, dam, and water systems are demonstrably

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providing the Taipei region with flood control and public water supply, together with the incidental benefits of sediment control and fish and wildlife conservation.

AID financing of the Shihmen project involved the provision of some $29 million plus the equivalent of more than $7.5 million in local currency. The Republic of China provided in excess of $300,000 in foreign exchange plus almost 1.4 billion in new Taiwanese dollars ($35 million equivalent).

In some instances only a small amount of AID seed capital is able to catalyze a chain reaction of economic development. The national revolving loan fund in Brazil demonstrates this possibility. This revolving loan fund established by AID, provides for financing water supply and sewerage system improvements. Over 200 cities, with 75 percent of the urban population of Brazil, have shown an active interest and over 100 are making feasibility studies to support proposals for long term loans to improve and expand their water systems. Qualifications for a loan include a sound administrative structure, adequate rates to cover fixed and operating costs, and municipal participation up to 33 percent of the construction costs. The loan fund is supported by a nationwide training and technical assistance program through Federal, State, municipal, and private agencies. Personnel from all the Federal and State agencies and more than 300 cities have benefited from training opportunities. All 28 engineering schools and 67 Federal, State, and municipal water and sewer departments are obtaining technical assistance from the program. By 1970 one of the objectives of Punta del Este—70 percent of the urban population, 30 to 35 million people served with safe water—will have been met.

During the period 1961–65 approximately $20 million annually was made available by AID through development loans and grants for community water supply and sewerage projects. From capital cities with elaborate underground supply systems to far off villages which draw their water from single wells or streams, there is a growing demand for technical and financial assistance to install safe systems of water supply. AID is responding to these urgent requests with loans and know-how. The loans are going principally to cities installing or improving their own water distribution and sewerage systems, specifically to, Saigon in Vietnam; Rangoon in Burma; Karachi, Pakistan; Monrovia, Liberia; Ibadan, Nigeria; Khartoum, Sudan; Dar-es-Salaam, Tanzania; Tunis; Fort Archambault in Chad; Nairobi in Kenya; Taiz in Yemen; San Jose, Costa Rica; Panama City; Bogotá, Colombia; Rio de Janerio and São Paulo in Brazil; Lima, Peru; and Seoul, Taegu, and Inchon, Korea.

In rural areas—where technical know-how is either missing or limited—villagers must be trained in elementary methods of construction and maintenance. The villagers provide the manual labor and building materials in return for technical guidance in drilling and wells and installing the pumps. In Latin American countries participating in the Alliance for Progress, assistance in constructing water and sewerage systems is tied to reforms in municipal administration, and most communities are also meeting one-third of the costs of construction.

In its efforts to increase food production AID is now providing assistance for 50 water projects in Africa, Asia, and Latin America which will open new land for cropping through irrigation, or permit multiple cropping. AID-assisted projects are irrigating several million acres in India and Pakistan. AID has also assisted in the development of large-scale irrigation projects in Tunisia, Morocco, Ecuador, Taiwan, Afghanistan, Thailand, the Philippines, and Korea.

AID has helped bring water to parched land by financing American steel, cement, machinery and engineering services for large dam-reservoir systems, by supplying American pumps and piping for tube wells, developing terrace and catchment systems for rainwater on riverless plateaus, and providing simple, low-lift pumps for delta soils too light to sponge up water lying just a few feet below ground level.

The developing countries need agricultural water more—and know less about the potentials of their water resources—than any other part of the world. AID has helped 14 countries undertake the first surveys of their own resources, and the mapping and exploration of new resources will be a key part of future AID-assisted water development programs.

In addition to its appropriated dollar funds, AID programs and administers certain U.S.-owned local currencies used for economic and social development purposes. For the most part these local currencies arise from the sale of agricultural commodities under Public Law 480. Over the past 10 fiscal years AID has committed over $897 million in dollars and equivalent of more than $1,417 million in local currencies for water resources development. Section 202 of title II of Public Law 480 permits the direct use of surplus agricultural commodities on a grant basis for economic development. This program is also administered by AID. These surplus commodities have been used extensively as payment in kind for labor on water devel-

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opment projects. From the inception of this form of assistance in fiscal years 1961 through 1965 over $416 million in commodities (at CCC cost) have been used for such activities as land terracing, building dams, digging irrigation ditches, etc., which have contributed significantly to the more effective use of water in many countries. The total of AID commitments for the past 10 fiscal years for water development under the various programs just described amounts to over $2,741 million in dollars or dollar equivalent. (See table 6 below.)

The Role of Private Groups and U.S. Agencies in the Foreign Assistance Program

In carrying out the foreign assistance program AID makes extensive use of private institutions, business firms, universities and service organizations and of other agencies of the U.S. Government to provide planning, supervision of construction, technical advice, and other professional services. The establishment of policies, the programing process, and the decisions to finance are made by AID, but the instrumentality chosen to implement the projects being financed is an outside entity. As a result of this policy the specialized knowledge and skills of a wide spectrum of groups and individuals are brought to bear directly upon the operation of U.S. foreign assistance.

Most of this outside participation comes from the private sector. Consulting engineers and other specialists from related professional groups are relied on to carry out such activities as surveys, feasibility studies, planning and design of systems, supervision of construction, and training of host country personnel in connection with the project. Many of these firms and individuals have developed a high degree of specialization in overseas water development. Universities and other U.S. firms and institutions engage in research, surveys, education and training and other technical assistance projects. Financing of these activities comes both under contract with AID from technical cooperation or development grant funds and under loans to countries for capital project construction or for feasibility studies. This private participation is in addition, of course, to the substantial volume of machinery, supplies and other commodities exported by American business and industry.

About 10 percent of the U.S. professional services financed by AID either directly by contract or agreement or indirectly from loans made to national governments are provided by other U.S. Government agencies. The arrangements for this type of intragovernmental cooperation are formalized by a "Participating Agency Service Agreement" (PASA) which defines the scope of the work to be done and provides for reimbursement of costs by AID.

The activities carried out by other U.S. Government agencies under PASAs with AID that relate to water development are many and varied. One of the largest of such programs in terms of money and manpower assigned overseas is that of the Bureau of Reclamation, administered by its Office of Foreign Activities in Washington and supported by the entire Bureau organization. Its principal projects include assistance to the Helmand Valley Authority of Afghanistan in the operation and maintenance of the Helmand Valley Project, training Afghans to operate the project for final takeover as soon as possible, and assistance in planning for development of the remaining service area; completion of a reconnaissance study of multiple-purpose development of the Blue Nile River Basin within Ethiopia and assistance in establishing a Department of Water Resources within the Ethiopian Ministry of Public Works; and provision of advisory services to ECAFE and the Lower Mekong Committee, including detailed study of the Pa Mong project in Thailand.

The Geological Survey of the Interior Department has provided a wide range of services relating to hydrology under PASAs with AID. These projects include ground water and surface water investigations in northeastern Brazil; ground water exploration and pilot development in the New Valley Project, Western Desert, Egypt; and hydrologic appraisal and monitoring in the Indus Plain, West Pakistan. Activities of the Bureau of Commercial Fisheries include assistance to the Government of Brazil in developing fresh water fisheries and a fish marketing program; and a study of methods and areas for harvesting lobsters on both coasts of Panama.

Because of the emphasis in the U.S. foreign assistance program on food production, AID has frequently turned to the Department of Agriculture for technical assistance in agricultural programs of which water development has been an important component in many cases. These include a pilot watershed demonstration project in Tunisia covering about 279,000 acres; assistance with new irrigation development in the Molouya River Basin in Morocco; and extensive participation in rural development programs in Nigeria. The departmental programs are coordinated through the International Activities Development Service, and include participation by the Soil Conservation Service, the Forest Service, the Economic

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TABLE 6.—*U.S. direct assistance for water resources development—Commitments by fiscal years*

[In thousands]

	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	Total
AID administered:											
Dollar programs	$50, 669	$47, 928	$81, 469	$74, 614	$225, 292	$38, 495	$59, 525	$129, 436	$108, 571	$81, 828	$897, 830
U.S.-owned local currency [1]	39, 935	48, 875	26, 570	258, 808	48, 520	126, 182	301, 031	220, 675	133, 940	185, 873	1, 417, 409
Title II, sec. 202, Public Law 480 [2]	.....	.....	.....	.....	.....	193, 159	157, 595	40, 510	20, 403	14, 948	426, 615
Total AID administered	90, 604	96, 803	108, 039	333, 422	273, 812	357, 836	518, 151	390, 621	262, 914	282, 649	2, 741, 854
Export-Import Bank	n.a.	n.a.	n.a.	n.a.	87, 852	22, 059	23, 832	4, 760	32, 002	31, 024	201, 529
Social Progress Trust Fund [3]	.....	.....	.....	.....	.....	.....	73, 229	32, 640	12, 435	30, 302	148, 606
Total direct U.S. assistance	90, 604	96, 803	108, 039	333, 422	361, 664	379, 895	615, 212	428, 021	317, 451	344, 975	3, 091, 989

[1] In dollar equivalents. [2] At CCC cost. [3] Administered by the Inter-American Development Bank.

n.a. = Not available.

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Research Service and the Agricultural Research Service.

AID has turned to the Department of the Army to carry out a number of important projects relating to navigation and river development and resources management. The largest of these is the design and construction of port facilities at Chisimaio in the Somali Republic, at a cost of $13,400,000. Other projects have included technical assistance and supervision of experimental contract dredging operations in connection with a study to determine the feasibility of providing a deep draft navigation channel in the Berbice River to New Amsterdam, Guyana; transportation surveys and reports of highways, railways, airways, ports, and waterways in East and West Pakistan; and preparation of general inventories of physical resources for a number of Central and South American countries.

Over a period of years the Department of Health, Education, and Welfare has supplied technical assistance on design criteria for construction of water supply and sewerage systems, malaria control, drainage operations, etc., in a number of countries participating in the AID program. Approximately 200 engineers and sanitarians of the Public Health Service have been involved in foreign water supply programs, including a number of direct assignments to the World Health Organization and Pan American Health Organization.

The work carried out by U.S. Government agencies for AID overseas has been supplemented by numerous education and training services in the United States for foreign nationals who come to this country. They also have undertaken publications exchange programs to make U.S. research findings and technical information available to interested countries, and have sponsored and participated in numerous international conferences.

Other U.S. Government Foreign Assistance for Water Development

Although, as we have noted, the AID programing process takes into account the total foreign assistance available, certain elements of U.S. foreign assistance and technical cooperation are not administered by AID. While these include a few instances in which U.S. agencies participate directly in technical cooperation, the primary sources of such assistance are the Export-Import Bank, the Social Progress Trust Fund, and the Peace Corps.

Although probably more than 95 percent of all the activity of U.S. water agencies in international matters is carried out under PASAs with AID, there are a few limited situations in which direct participation is authorized and funded, subject to the overall coordinating authority of the Department of State. Both the Office of Saline Water and the Atomic Energy Commission have limited authority to participate in research projects and development studies; each, for example, contributed one-fourth of the cost of financing a recently completed engineering feasibility and economic study of a nuclear dual-purpose power and desalination plant in Israel (Israel contributed one-half the cost). The Department of the Interior also sent a team to Saudi Arabia to help investigate desalting potentialities, and cooperative studies are underway with Mexico. The Public Health Service and Department of Agriculture agencies have engaged in research and studies having direct application to international health and agricultural problems.

In a few instances, U.S. agencies have provided services on a reimbursable basis for national and international agencies. Examples of this kind are the assistance which the Bureau of Reclamation is providing to the Snowy Mountain Hydro Electric Authority of Australia on the design and construction of a large transmountain diversion and storage project for the development of hydroelectric power and irrigation; and the Caribbean Fisheries Survey undertaken by the Bureau of Commercial Fisheries on behalf of the U.N. Special Fund and the Food and Agricultural Organization.

The Export-Import Bank of Washington, which was organized in 1934 for the purpose of financing U.S. exports and imports, has made many loans for water resources development. It is the policy of the Bank not to compete with private capital and to only make loans repayable in dollars. Data on EXIM loans are not available classified by specific purpose prior to fiscal year 1961. In the 6 fiscal years 1961 through 1965, EXIM has made loans of approximately $427 million for water resources development.

The Social Progress Trust Fund is a fund of $525 million contributed by the United States and managed by the Inter-American Development Bank. This fund, which was one of the elements of the Latin American development program covered by the Act of Bogota, has the following purpose:

The fundamental purpose of the Fund is to provide financial resources and technical assistance, on flexible terms and conditions, to support the efforts made by the Latin American countries that are prepared to undertake effective employment of their own resources toward achieving greater social progress and more bal-

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anced economic growth. (Section 1.03 of the SPTF Agreement).

The SPTF was established in 1961 through an initial U.S. commitment of $394 million. In 1964, the United States added $131 million to the Trust Fund. The resources of the SPTF have been utilized to provide loans and technical assistance designed to encourage progress in the member countries in four fields of activity, one of which is community water supply and sanitation.

The existence of the Trust Fund has enabled the IDB to operate in fields previously not considered suitable for international lending agencies. From its creation in 1961 through December 31, 1965, some $162 million has been lent by the Trust Fund for water projects. (See table 6 for data by fiscal year.) The SPTF lending operation of the IDB have now been absorbed by its Fund for Special Operations, which is financed by joint contributions of the member countries, including the U.S. Government.

The Peace Corps was established in 1961 as an agency within the Department of State. The Peace Corps arranges for the placement abroad of U.S. volunteers in developing nations to help fill these nations' critical needs for skilled manpower. In this program of assistance, Peace Corps volunteers, carefully selected and well-trained, serve for periods of 2 years teaching, building, or working in the communities to which they are sent. The Peace Corps conducts a type of "grass roots" technical assistance program and helps to direct and carry out work projects. Community water supply and other water resources development are included in its public works programs. Quantitative data on Peace Corps activities in the field of water resources development are not available.

The U.S. programs described above have committed more than $2 billion (or dollar equivalent of local currency) for water resources development over the past 5 fiscal years.

B. Other Bilateral Programs

Of the total flow of foreign assistance to the less developed countries, the U.S. bilateral contribution, as noted above, is by far the largest element. Next in magnitude is that of other bilateral donors collectively. The most important association of bilateral donors is the Organization for Economic Cooperation and Development (OECD), which was formed in 1961 under the sponsorship of the Organization for European Economic Cooperation (OEEC). This body in turn was formed in 1948 to allocate Marshall Plan aid and to work together to restore the economies of the European countries after World War II. Twenty-one countries are members, including, outside of Europe, the United States, Canada, and Japan. OECD serves as a forum for discussion and coordination of economic, scientific and trade problems of mutual interest, including the coordination of programs of aid given to the developing countries.

Coordination of the bilateral assistance extended by most of the OECD countries is provided through the Development Assistance Committee (DAC), which was created in 1960 to provide a central point where suppliers of assistance to less developed countries might consider together common problems such as the volume, form, organization, and effectiveness of assistance efforts. DAC has no funds of its own but is rather a center where new policies, problems and practices are discussed and old ones reviewed. DAC is made up of 15 countries, Australia, Austria, Belgium, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Sweden, the United Kingdom, and the United States in addition to the Commission of the European Economic Community is also a member. Assistance extended by DAC members excluding the United States amounts of about 60 percent of U.S. bilateral aid.

In the 6 years 1960 through 1965 U.S. bilateral assistance amounted to about $21 billion whereas for the DAC countries excluding the United States the figure was $14 billion. These data are for calendar years and computed on the basis of different assumptions than the figures shown in table 6 and hence are not comparable. The figures in table 6 are for *commitments* by *fiscal* years for *water* projects whereas those in table 7 are for expenditures by *calendar* years for *all projects*. It should be apparent that any new assistance program must have the cooperation and financial support of DAC and other countries providing foreign aid if it is to be successful.

Information is not available on the proportion of non-U.S. bilateral assistance going to water resources development. It is reasonable to assume that it has about the same significance as it does in relation to total U.S. assistance. U.S.S.R. assistance for the construction of the Aswan Dam serves to illustrate how important bilateral aid for water resources development can be.

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TABLE 7.—*The flow of official bilateral assistance for all purposes—Expenditures by calendar years*

[In millions]

	1960	1961	1962	1963	1964	1965	Total
DAC members,[1] excluding United States	$2, 155	$2, 577	$2, 443	$2, 370	$2, 420	$2, 515	$14, 480
Sino-Soviet	186	294	391	425	n.a.	n.a.	[3] 1, 296
Other [2]	82	101	87	109	n.a.	n.a.	[3] 379
Total	2, 423	2, 972	2, 921	2, 904	2, 420	2, 515	16, 155
United States	2, 834	3, 530	3, 671	3, 755	3, 463	3, 766	21, 019
Total	5, 257	6, 502	6, 592	6, 659	[3] 5, 883	[3] 6, 281	[3] 37, 174

[1] Australia, Austria, Belgium, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Sweden, United Kingdom.

[2] Finland, New Zealand, South Africa, and Switzerland. Certain other countries, e.g., Israel, the Republic of China (Taiwan) extend foreign assistance; however, their contributions are not included in the data given since these countries are net recipients of foreign assistance.

[3] Sino-Soviet and "Other" data for 1964–65 not included in totals.

n.a.=Not available.

C. The United Nations and the Specialized Agencies

Many U.N. entities are deeply involved in water resources development offering both technical and capital assistance. In the following paragraphs the pertinent functions and activities of these agencies are described briefly.

The Economic and Social Council (ECOSOC)

Working under the authority of the United Nations General Assembly, the Economic and Social Council examines and makes recommendations on international economic, social, educational, health and related issues, and calls international conferences when needed. Composed of 27 member states, nine of which are elected each year by the General Assembly for a 3-year term, the Economic and Social Council meets as often as is required to perform its duties, usually for two sessions a year.

Regional Economic Commissions

There are four regional economic commissions which report to the Economic and Social Council: The Economic Commission for Europe (ECE), the Economic Commission for Asia and the Far East (ECAFE), the Economic Commission for Latin America (ECLA), and the Economic Commission for Africa (ECA).

U.N. Secretariat

The U.N. Secretariat is represented in the field of water resources through the Department of Economic and Social Affairs. More particularly, on the substantive side, the work at headquarters is done through the Resources and Transport Division (UNRTD), and the work on the regions by the secretariats of the regional economic commissions. On the administrative side, the Department is represented by the Bureau of Technical Assistance Operations (BTAO), which administers U.N. technical assistance.

The Resources and Transport Division is responsible, in the field of water resources, for overall surveys designed to meet multiple objectives, reconnaissance of river basins, groundwater inventories, certain narrower phases of water resources such as hydropower development, river navigation, water for industry and desalination and conveyance of water, and for such other subjects as do not fall within the competence of the specialized agencies. In addition, the Division is responsible for research and substantive support of U.N. technical assistance.

The Water Resources Development Center under UNRTD serves as a clearinghouse for the assembly and dissemination of information on water matters and

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for the study of administrative, legislative, and related aspects of water problems.

U.N. Development Program (UNDP)

The U.N. Development Program is a recent amalgamation of the U.N. Special Fund (SF) and the U.N. Expanded Program of Technical Assistance (EPTA). The UNDP provides funds for preinvestment surveys, such as resources surveys and feasibility studies, and for technical assistance, such as applied research and training and technical education institutes. Projects approved under this program are executed by the U.N. Secretariat or by one of the other organizations of the U.N. system. In recent years the predecessor groups (SF and EPTA) have financed water resources activities (excluding hydropower) at a rate of about $12 million per year.

The World Bank Group

The International Bank for Reconstruction and Development (IBRD), and its affiliates, the International Development Association (ID) and the International Finance Corporation (IFC), provide funds in the form of loans to finance economically productive projects of high priority in member countries. The IBRD, organized in late 1945, concentrates on so-called "hard loans" with generally higher interest rates and shorter repayment periods; IDA, formed in 1960, makes relatively "soft loans" with lower rates and longer terms; and IFC, a separate but affiliated corporation established in 1956, specializes in investment in manufacturing enterprises, often on a mixed loan and equity basis, and in standby and underwriting arrangements.

Funds are derived from both public and private sources, and the Bank group regularly makes a profit on its lending operations. Particular emphasis has been given to projects in the fields of transportation and electric power, which together account for two-thirds of all lending. Other specific economic sectors include industry, agriculture, water supply, communications and since 1960, education. In the 19 years since the Bank started, total loans for single-purpose and multiple-purpose power projects amount to approximately $3,256 million, and for other water projects, to $340 million.

The Food and Agriculture Organization of the United Nations (FAO)

The purview of the FAO in the field of water resources is the investigation and development of surface and ground water resources in relation to agriculture, which also includes forestry and watershed management, and fisheries.

The U.N. Educational, Scientific, and Cultural Organization (UNESCO)

UNESCO concentrates, as regards water resources, on the scientific and educational aspects involved, including the provision of the secretariat for the International Hydrological Decade.

The World Health Organization (WHO)

WHO provides special competence on all aspects of community water supplies and waste disposal. It is also concerned with the reduction and prevention of water-borne and water-related diseases on all projects involving water resources development, and with the control of pollution.

The World Meteorological Organization (WMO)

WMO work in the field of water resources is principally in the field of hydrometeorology, which includes surface hydrology.

World Food Program (WFP)

This program, undertaken jointly by the United Nations and the FAO, assist economic and social development, including water projects, mainly through contributions in kind.

The International Atomic Energy Agency (IAEA)

The IAEA plays a role in the field of water resources through its activities relating to research, development and application of isotope techniques in the investigation and development of water resources, the application of nuclear energy to desalination, and also through its competence as regards the disposal of radioactive wastes.

D. Regional and Subregional Groups

There are a large number of regional and subregional intergovernmental entities which are involved to a greater or lesser degree in water development activities. Within the U.N. family the regional economic commissions mentioned above (ECA, ECE, ECAFE, and ECLA) play important roles. Most of the U.N. specialized agencies have regional branches. Chapter IV discussed briefly the international river

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basin commissions, as well as the international consortia which function in certain situations.

Finally, there are many special or general intergovernmental groups which become involved in water matters through the sponsorship of studies, conferences or institutes, exchange of information, coordination of policies, or provision of technical assistance. In addition to the organizations separately described below, this category includes such diverse entities as the Afro-Asian Rural Reconstruction Organization (AARRO), the Caribbean Organization, the Central Treaty Organization (CENTO), the Colombo Plan Council for Technical Cooperation in South and Southeast Asia, the Commission for Technical Cooperation in Africa (CCTA), the League of Arab States, the Organization of African Unity (OAU), the Organization of Central American States (OCAS), the South Pacific Commission (SPC), and the Southeast Asia Treaty Organization (SEATO).

Organization of American States (OAS)

The Organization of American States, consisting of the 21 republics in the Western Hemisphere, was organized in 1948 as an outgrowth of a series of hemispheric cooperative arrangements which began in 1890. The Pan American Union serves as its secretariat. In 1961 OAS endorsed the Alliance for Progress, a far-reaching 10-year program of economic and social development heavily supported by the United States.

Inter-American Development Bank (IDB)

The Inter-American Development Bank is a regional hemispheric agency created in 1959 to accelerate economic development of member countries through promoting investment of public and private capital for development purposes and providing technical assistance for the preparation, financing, and implementation of development plans and projects. The Bank also administers the Social Progress Trust Fund discussed above. As of March 1966, loans for water projects, comprising approximately one-fourth of its loans authorized to date, amounted to $425 million, and the total costs of these water projects exceeded $1 billion. In addition, the IDB has made a number of reimbursable and nonreimbursable technical assistance grants for preinvestment studies and resource investigations, and expanding its support for country-wide surveys and preinvestment feasibility studies.

Pan American Health Organization (PAHO)

The Pan American Health Organization traces its lineage back to the International Sanitary Bureau established in 1902, which in turn became the Pan American Sanitary Bureau in 1923. The purpose of the Organization is to promote and coordinate efforts of the countries of the Western Hemisphere to promote the physical and mental health of the people, and it serves as the regional office of the World Health Organization. PAHO's programs encompass technical collaboration with governments in the field of public health, including such subjects as sanitary engineering and environmental sanitation, community water supply, maternal and child health, and eradication and control of communicable diseases.

Asian Development Bank

Through international agreements the Asian Development Bank is being established to finance economic development projects in Asia. Congress authorized the appropriation of $200 million as the United States contribution to this institution's total capital of $1 billion.

African Development Bank

An African Development Bank has been established by the developing countries of Africa to provide among themselves lending facilities similar to those of the Inter-American and Asian Development Banks. It has not yet begun its lending functions. Unlike these other Banks, the African Bank has no developed countries as members either from within or from outside the region.

E. Private Groups and International Associations

The work of governments in international water development is supplemented by the activities of an extremely large number of private organizations. From the United States alone, at least 60 voluntary agencies, missions and foundations provide assistance in water development projects overseas related to food production and sanitation. Many U.S. corporations operating overseas, particularly oil companies, develop water supplies for their own uses and cooperate with local governments in water activities.

Additionally, there are approximately 1,500 international nongovernmental associations engaged in exchanging information and fostering studies and cooperation in practically every aspect of human endeavor. Many of these are concerned with some phase of water problems. The following is a partial list of those having a particular interest in the subject: Inter-

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American Association of Sanitary Engineering, International Association for Hydraulic Research (IAHR), International Association of Hydrogeologists, International Association of Meterology and Atmospheric Physics (IAMAP), International Association of Scientific Hydrology (IASH), International Association of Sedimentologists, International Association of Soil Science (IASS), International Association of Theoretical and Applied Limnology (IAL), International Association on Water Pollution Research, International Commission of Agricultural Engineering, International Commission on Irrigation and Drainage (ICID), International Commission on Large Dams of the World Power Conference (ICOLD), International Geographical Union (IGU), International Union of Geodesy and Geophysics (IUGG), International Water Supply Association (IWSA), Permanent International Association of Navigation Congresses (PIANC), and the World Power Conference.

F. International Scientific Programs

From time to time scientists throughout the world have cooperated in international programs to advance man's collective knowledge about the natural environment in which he finds himself. The three programs described below have particular significance to the Water for Peace Program.

International Hydrological Decade

Growing recognition of hydrology as a unified science and profession has emerged in recent years with the awareness that fragmented and single-focus efforts to understand, to manage and to develop water resources cannot succeed in the face of the massive demands placed upon them. Efforts to stimulate international cooperation in hydrology were initiated by the United States in 1961 through discussions in several international forums. In the spring of 1964, UNESCO convened an intergovernmental meeting of experts in Paris to discuss formulation of an international cooperative program. This led to the formal adoption by UNESCO, at its 13th session in November 1964, of a resolution calling on interested countries to establish national programs within the framework of an International Hydrological Decade to begin in 1965. Pursuant to this resolution a coordinating council for the Decade consisting of 21 rotating members had been established and held its first session in May–June 1965.

Approximately 100 member states are participating in the program, and most of these now have formed national committees to coordinate their activities in the program. The U.S. National Committee for the International Hydrological Decade, consists of 21 U.S. scientists from inside and outside of government. The committee functions under the National Academy of Sciences-National Research Council (NAS-NRC), which provides a small secretariat.

The International Hydrological Decade will promote worldwide assembly and analysis of information about water, its quantity, its distribution, and its behavior. It will also serve to promote worldwide realization that a science of hydrology exists, that teaching, training, and research must be expanded greatly, and that many varied career opportunities are open for hydrologists. Specific activities in the program will include the assembly of basic data about water, the preparation of inventories of water and the study of water balances, including its chemical quality and its sediment load. Requirements for water will be studied. Many countries plan to establish representative and experimental basins. Also included will be education and training programs; fellowships and exchanges; and numerous supporting activities, such as standardization of instruments, methods, units of measure and terminology, advice on data network design and operation, and dissemination of information including publication of handbooks, manuals, and textbooks.

Strong support for the International Hydrological Decade is uniquely appropriate for inclusion as part of the Water for Peace Program. Both share the common objective of promoting attention to water as a separate subject for study and development. IHD will have a major responsibility for the scientific aspects of the Water for Peace Program dealing with hydrology, as well as for sponsoring of education, training, and scientific exchanges in hyrology. Consequently, it is important to implement the U.S. effort for IHD as soon as possible in line with the program of the U.S. National Committee.

International Biological Program

The International Biological Program is a cooperative scientific effort initiated by the International Council of Scientific Unions. About 48 countries, including the United States, are participating in the planning. The objectives of the IBP are to stimulate and coordinate comparative studies, in contrasting environments, of organic production, nutrient cycles and system regulation on the land, in fresh waters

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and in the seas; and of the adaptability of man as a component and manager of these ecosystems.

World Weather Watch

The World Weather Watch is a program sponsored by the World Meteorological Organization as an international undertaking aimed at the improvement of weather services for all the nations of the world. It is a system for the observation, collection, processing, and dissemination of global weather data using the most recent developments in space, communication, data processing, meteorological, and instrumentation technology. It is an essential step toward developing the capability for improving forecasts of precipitation and resultant streamflow, as well as a basic requirement for large-scale weather modification.

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VI. ORGANIZING FOR IMPROVED COOPERATION

Chapter III has described in summary form the activities required for water resources development principally from the point of view of national and local programs. Chapter IV touches upon opportunities for regional cooperation in international river development. Chapter V briefly reviews the impressive array of public and private, bilateral and multilateral programs now actively functioning to promote international cooperation in local, national, and regional development.

The proliferation of programs throughout the world is not surprising in view of the fact that water is directly involved in so many diverse human activities. The problem of coordinating such activities at all levels within the unified framework of water as a separate object of study and development, has always been one of the most critical handicaps to water progress and probably always will be. Ideal coordination can never be attained and probably is not even desirable, for the wide diversity in individual desires and group traditions makes complete uniformity unacceptable under any system of human values.

In endeavoring to assess how the existing system functions and where practical improvements in mutual cooperation might be feasible, it is necessary to adopt a pragmatic approach. Such an effort has been made in the course of preparing this report. It has led to the general conclusion that, in addition to suggestions for organization and coordination discussed in chapter III, possible improvements in mutual cooperation are indicated within the U.N. family, at the regional and subregional levels, and within the United States itself to facilitate its contribution to the international effort. Discussion of these proposals can usefully be furthered by the forthcoming International Conference on Water for Peace.

A. Within the U.N. Family

The current activities of the United Nations and the specialized agencies in water matters reflect the complexity and diversity of water development responsibilities in national and regional programs. Serious attention has been given to the necessity for coordinating these varied activites, and many useful coordinating mechanisms and institutional arrangements exist. The meetings and staff activities of the Economic and Social Council offer an invaluable forum for discussing common problems. There exists under the chairmanship of the Secretary-General an Administrative Committee on Coordination (ACC) composed of the leading officials from the U.N. Secretariat and the specialized agencies. This Committee has a Subcommittee on Water Resources, which includes representatives of all concerned agencies. Regular interagency meetings attended by representatives of these groups are held to discuss mutual problems. The Water Resources Development Center located under the Resources and Transport Division serves as a clearinghouse for water information and as a stimulus to the study of selected water problems.

Regional coordination is facilitated through the regional economic commissions and regional branches of the specialized agencies. At the regional and country levels, considerable success has been obtained through the assignment of field representatives to those areas where sizable U.N. technical and financial assistance programs are being carried out. At the end of 1964 there were regional or resident representatives in charge of 7 regional and 60 country suboffices.

In general, this complex fabric of interacting arrangements works surprisingly well in view of the magnitude and variety of the programs, the institutional traditions prevailing, and the political sensitivities involved. Nonetheless, it is felt that, in addition to strengthening these existing coordinating mechanisms, one additional institutional arrangement would be useful. This would be the establishment of an intergovernmental committee on water questions functioning under the Economic and Social Council. This committee might consist of representatives of 24 governments serving on a rotational basis. Such a

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committee would stimulate interest by member governments in water problems and serve as a forum to bring interested agencies together to reach decisions to formulate policy guidance and stimulate action. It would facilitate the task of following through on projects suggested by the Water for Peace Program and on matters discussed at the proposed international conference. The U.N. Advisory Committee on the Application of Science and Technology to Development is a successful precedent.

B. Regional and Subregional Institutions

Technical assistance resources are limited and must therefore be employed with the utmost efficiency. There are congeries of water problems and similarities of hydrological circumstances which suggest that the geographic concentration of technical assistance skills may offer the most efficient method for their employment. What is needed is a system of regional and subregional centers to serve all the nations of the region. The desirability of such regional cooperation and regional organization seems universally accepted. For example, the report of the U.S. delegation to the United Nations Conference on the Application of Science and Technology to the Developing Nations, held in Geneva in 1963, states at page 6:

Regional cooperation in a variety of forms was advocated repeatedly by many delegates from less developed countries. Regional training facilities, research facilities, advisory services of various types, and conferences (particularly to treat in greater depth many subjects raised during the UNCAST discussions) were suggested. More frequently than not, United Nations auspices were favored.

In his last foreign aid message, President Johnson stressed the importance of fostering regional cooperation:

In many areas, the keys to economic and social development lie largely in the settling of old quarrels and the building of regional solidarity. Regional cooperation is often the best means of economic progress as well as the best guarantor of political independence.

I propose that we continue and enlarge our support of the institutions and organizations which create and preserve this unity.

It is apparent that a number of separate but related regional development functions are required: (1) Expert advisory services to national and local governments and river basin commissions, including specialized training programs for government personnel; (2) information assembly, retrieval and dissemination; (3) data assembly, retrieval, and dissemination; (4) sponsorship of conferences and seminars; (5) professional training (university undergraduate and graduate level); (6) subprofessional training (technical and vocational education level); and (7) research. Collectively these functions are too diverse to be made the responsibility of a single institution. Additionally, the requirements of each center will differ and the kinds of services to be rendered initially would depend upon the greatest apparent need. At the same time, while none of the centers could take on all functions at the start, they might expand their services as operations become stabilized and experience has been gained.

It might be found desirable to associate the centers with universities offering undergraduate and graduate training in water-related disciplines, with research institutions, or with other existing organizations possessing competence in water fields.

A center or other institution or program can function most effectively if it serves a region or subregion with relatively common problems. The factors that should be considered in selecting the region to be served by a center include: (1) Similarity of hydrological conditions; (2) political traditions; (3) language problems; (4) population density; (5) extent of need for additional expert assistance; and (6) availability of existing competence and facilities.

The internal organization and sponsorship of each center or other institution will vary from case to case depending on the individual situation, but it is to be hoped that each will be consistent with an eventual system providing complete coverage of the developing world in terms both of geography and of program. Where appropriate, existing regional and subregional international entities, particularly the regional economic commissions of the United Nations, can be expected to provide leadership in establishing the necessary institutional arrangements. The joint cooperation of countries within the region or subregion is essential to the success of each center, and they should clearly establish their determination to provide long-term financial and institutional support. Additionally, the opportunity to participate in the staffing, financing or operations of each institution should be offered to all United Nations entities and the specialized agencies, to interested countries outside of the region or subregion, and to private groups. The United States should be prepared to play an active role in fostering the strengthening or establishment of a network of such centers or institutions by encouraging appropriate in-

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tergovernmental discussions and by offering to provide expert assistance, supplies and equipment, and financing.

Although the seven major functions described above are interrelated, and may be joined in varying combinations, their implementation presents a number of different administrative and institutional considerations. These generally may be considered to fall into four groups, namely, centers for water resources development, professional education, subprofessional and technical training, and research. There follows more detailed comment on the special considerations within each group.

Regional Centers for Water Resources Development

Early emphasis needs to be given to strengthening the capability of national and local governments, and regional river basin commissions, to plan and administer water development programs. To achieve this objective, it is desirable to establish a number of regional centers for water resources development. The most important functions to be established initially in these centers would presumably be: assembly, retrieval and dissemination of information about water needs and development; provision of expert advisory services to national and local governments and river basin commissions, including specialized training sessions for government personnel; and sponsorship of conferences and seminars to discuss general and technical problems of mutual concern. These centers might also provide assistance with respect to data assembly, retrieval, and dissemination.

At least two existing institutional groups provide or are planning to provide at least some of the kinds of services envisaged for the proposed regional or subregional centers. The first of these groups is the very excellent staff of water resource experts in the Secretariat of ECAFE in Bangkok. This group for a number of years has conducted regional conferences and seminars, prepared and published technical papers on water resource subjects as well as publishing the proceedings of the conferences and seminars, and provided expert advisory services.

The second group is the Inter-American Center for the Integrated Development of Water and Land Resources, recently established by the Organizations of American States. Located on the campus of the University of the Andes at Merida, Venezuela, the center has a staff of eight professionals, not more than three of whom are from any one country. The language employed is Spanish. Utah State University has entered into a 6-year contract with OAS to direct the Center. Funding is through OAS, the Venezuelan Government, and the University of Los Andes. The center gives instruction to top-level, middle-management, and junior-grade government personnel through 2-week, 2-month, and 6-month courses. Initially the center is concentrating on irrigation and agricultural development subjects.

In addition to expanding the capabilities of these two institutions, comparable and complementary centers should be established in other regions or subregions where similar capabilities do not exist. A reasonable goal might be to launch or to strengthen nine new centers by 1970. The sponsoring organizations and participating countries should clearly establish their determination to provide long-term support for each institution. Although the costs of operating such centers are impossible to estimate with any precision in advance of knowing the details of the proposed operation, the average annual costs for the early years might range between $750,000 and $1,300,000 for each center.

Regional Institutions for Professional Education

The typical institution for professional education is a university giving formal course work at the undergraduate and graduate levels in basic studies and in professional specialties. Many of these bear on water management, including engineering, agriculture, economics, anthropology, the natural sciences, law and public administration. Understandably, each country of the developing world would prefer, for reasons of prestige, to have its own university complex providing all necessary course work. The cost of establishing and operating such an extensive network of university institutions makes this prohibitive, however, let alone the fact that there are not enough trained persons in the world to staff them. This is especially true with respect to the diverse professional specialties needed to carry out water development programs, which require, in addition to basic education in traditional professional disciplines, special instruction in the application of these skills to water management.

For these reasons, an important concern of the Water for Peace Program should be to foster a significant expansion in undergraduate and graduate education in water-related professional skills. This objective can only be attained through subregional, regional, and global cooperation. A number of concurrent steps

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should be taken including strengthening of existing university programs and creation of new institutions to serve regional and subregional needs, the introduction of special courses, faculty exchanges, fellowships for third-country education, publication of textbooks, sponsorship of conferences and seminars, and support of professional associations.

There are several existing or planned institutions which provide some of these functions. The Southeast Asia Treaty Organization sponsors the SEATO Graduate School of Engineering at Chulalongkorn University of Bangkok, Thailand, which includes graduate studies and training in hydraulics and public health. In 1965, there were 26 graduate students in these 2 curricula doing research and studies under 8 instructors. AID has provided substantial assistance to the school through a contract with Colorado State University Research Foundation. Consideration is being given to proposals to make the school an independent regional institution with permanent faculty and assured financing.

The United Nations Development Program is assisting UNESCO in the development of the Middle East Technical University in Ankara, Turkey, which includes a department of sanitary engineering, as well as supporting sanitary engineering research and training centers in India, Brazil and Venezuela. The American University in Beirut (AUB) has become an outstanding educational center in the Middle East and a major training center for African leaders as well; some of its course work relates to water subjects. The International Hydrological Decade is providing the stimulus for the conduct of special postgraduate courses in hydrology and for the establishment of educational programs in hydrology at existing universities to serve regional, and in some cases, worldwide needs.

Regional Programs for Subprofessional Training

The need for subprofessional training is too often overlooked as an essential component of any water development program. At least three technicians are required to support each professional: and the number of skilled workers needed is many times greater. This is particularly true in the developing countries, where illiteracy rates are high, the number of individuals with formal education of any kind is extremely small in relation to the demand, and many professionals are unwilling to engage personally in the "dirty work" that U.S. professionals take for granted as part of their responsibility for getting a job done.

Although it is possible on occasion to combine technical and vocational training with university programs, experience demonstrates that the former usually require separate institutional arrangements. Because of the nature of the training and the large numbers of people involved, a high proportion of technical and vocational training has to be provided locally. The establishment of technical and vocational schools is important, adequately equipped with shop and laboratory equipment, and offering instruction at the secondary level and technical training for up to 3 years for secondary-school graduates. On-the-job training also is significant. Regional and subregional cooperation can be enlisted to enhance these training programs through such measures as contributing facilities, publishing textbooks and teachers' manuals, and training instructors both for the schools and for conducting on-the-job training courses. Another valuable form of regional cooperation is the sponsorship of short-term courses or institutes for technical and operating personnel. AID has cooperated in launching a successful effort of this kind through regular institutes for waterworks personnel in Latin America, particularly the session now held annually in Bogotá, Colombia.

In addition to these regional programs to support local instructional efforts, there is a need to establish permanent schools under regional or subregional sponsorship to provide training in technical specialties that is beyond the capability of national and local programs. These schools could be operated as independent institutions or combined with the regional centers for water resources development. One successful example of this kind in a related field is the Cartographic School in the Canal Zone sponsored by the Inter-American Geodetic Survey (IAGS). The IAGS was created in 1946 as a special unit of the U.S. Army Corps of Engineers to serve as a coordinating agency to carry out a cooperative international program, agreed to by the participating governments, for the geodetic control and mapping of Latin America. Soon after the program started, it became apparent that the training of Latin American technicians in the various phases of geodesy and cartography would be an important factor in attaining the objectives of the program. Consequently, the IAGS Cartographic School was established in 1952 to provide practical training for technical and supervisory personnel. Two school terms each year offer courses ranging from 4

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to 16 weeks in duration. All courses are given in Spanish by bilingual instructors.

Regional Centers for Tropical Research

The need for more scientific research into the unique water problems of tropical areas has been discussed in chapter III. Expanded research efforts along these lines should be carried out within the framework of regional and subregional cooperation. Several alternative arrangements are possible. A research operation might be established separately, or it might be associated with a regional center for water resources development, with a regional university or training center, with a national university, or with an existing research institute. In any event, participation by other universities within the region should be enlisted.

C. Within the United States

If the United States is to fulfill its commitment to support the Water for Peace Program, a number of organizational steps will be required to mobilize the entire U.S. expert competency in water matters within and outside of Government. The discussion that follows outlines some of these steps.

The Water for Peace Organization

There should be a focal point within the U.S. Government to coordinate the multiple activities of a number of Government departments and agencies that can be expected to become increasingly involved in international water activities. The Department of State, of course, must be looked to for final coordination and approval of all Water for Peace activities involving our relationship with foreign governments. The Agency for International Development will continue to be heavily involved in the administration of U.S. programs for financial and technical assistance abroad. In recent years, however, AID has followed the practice of contracting out an increasing portion of the responsibility for program execution to outside entities. While most of these contractual arrangements have been made with universities, consulting firms and other private organizations and individuals, a small but significant role has been played by Federal departments and agencies having expert competence in a particular phase of water programs. Under the stimulus of the Water for Peace Program, an increase in their role can be anticipated. As has been pointed out earlier in this report, for example, a primary focus of the Water for Peace effort will be to assist national governments and regional intergovernmental entities in planning and administering their water development programs. In countries where AID does not operate, this help might be provided on a reimbursable basis. Provision of such assistance can be enhanced through the establishment of teams of experts possessing the skills necessary for each assignment. Representatives from U.S. Government agencies will be expected to make an important contribution along these lines because of their intimate involvement in similar governmental responsibilities within the United States.

The launching of the Water for Peace Program also coincides with the opening of a new chapter in international scientific and technical cooperation. One evidence of this is the International Hydrological Decade. Another is the recent U.S. Natural Resources Mission to Germany, headed by Secretary of the Interior Udall. In its report the Udall Mission recommends the formation, by the Federal agency head most concerned, of teams of experts representing a broad cross-section of U.S. competency from Federal and State governments and the academic, scientific, and industrial communities, in cooperation with German counterparts to engage in research and study projects dealing with five areas of natural resources conservation and management. One of the areas named is the abatement of water pollution. The formation of similar teams should be encouraged under the Water for Peace Program to deal with other aspects of water development, and the range of cooperation extended to other countries and international and regional organizations. Such efforts will, of course, be carried out under the overall coordination responsibility of the Secretary of State in international affairs. Appropriate funding and, depending on the scope of these expanded cooperative efforts, possible revision in existing legislative authority, will be required.

The Water for Peace organization within the U.S. Government should have a base in a Water for Peace office. This office should be established within an existing department or agency which can provide appropriate supporting services. Other interested agencies should be encouraged to furnish experts to the central office. Overall guidance would be provided by an Interdepartmental Committee on Water for Peace at the Assistant Secretary level. This Committee would consist of representatives from the Departments of State, Interior, Agriculture, Army, Commerce, and Health, Education, and Welfare; the Tennessee Valley Authority; the Atomic Energy Commission; and the Agency for International Devel-

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opment; with participation as appropriate by representatives of the Treasury Department, the National Science Foundation, the Bureau of the Budget, the Office of Science and Technology, the National Academy of Sciences, the National Research Council, and the new National Academy of Engineering. Each of the participating U.S. Government agencies, particularly AID, should be encouraged to establish Water for Peace liaison units at a sufficiently high level.

The following are listed as among the principal tasks to be performed by the Water for Peace organization:

1. Coordinate policy and provide guidance to U.S. Government departments and agencies in their Water for Peace activities, including followup to the International Conference on Water for Peace.

2. Maintain liaison with, and assist and encourage U.S. Government departments and agencies, international and regional organizations and agencies, and nongovernmental organizations and institutions engaged in international water resources development, with due regard to established channels.

3. Assist in arrangements for research and studies; planning assistance; education and training programs; conferences, seminars, advisory committees; fellowships; and other similar activities related to the Water for Peace Program.

4. Collect and evaluate information on international water resources development, especially the programs carried out by the United States, and prepare an annual situation report to the President.

Careers in International Water Service

It is obvious that United States support for a Water for Peace Program will require a commitment by increased numbers of U.S. citizens in government and private life to professional careers in international water service. AID reports that even though it is relying more heavily on contracting for expert services from outside the Agency, it still is having difficulty in recruiting component personnel trained in water matters to handle its in-house requirements for supporting its growing activities in water resource development. The expanding horizon for greater participation by other U.S. departments and agencies will require many more career employees who, while retaining their identity with the domestic agency, focus an important part of their professional careers on international water problems. An increasing number of opportunities will develop for professional assignments outside of Government with universities, private industry, foundations and other nonprofit groups, research institutes, and international and regional organizations. Accordingly, an important effort should be made at all possible levels to bolster support for professional careers in international water activities.

Within the Federal Government, a number of useful steps can be taken to strengthen and improve existing personnel policies supporting this effort. Government agencies should cooperate fully in carrying out the spirit of the Presidential Memorandum of August 15, 1964, urging Federal agencies to assist international organizations in obtaining the services of qualified Federal employees. Legislation should be enacted to amend the Federal Employees International Organization Service Act to extend the time period for approved assignment with international organizations from 3 to 5 years, and to provide the difference in salary and allowances between the international post and a comparable U.S. Government post when a Federal employee returns to his host agency within this time period following approved employment with an international organization.

All affected Federal agencies should adjust their policies and practices to encourage qualified personnel to serve overseas in the water field. This might be done through offering short-term assignments when longer ones are not practical, providing opportunities for further study and service on a sabbatical basis, giving instruction in foreign languages, and encouraging professional study and discussion of overseas water problems that are related to domestic problems, particularly with respect to research projects.

Consideration should be given to the establishment of a limited number of positions of senior water service fellows, if a sufficient number of Federal employees are interested in climaxing their careers by accepting advisory positions abroad during the last 3 or 4 years of Federal service. These experts could be available to advise and assist American embassies, foreign governments, regional centers and international organizations on a wide range of regional water problems. Experts with an interest in the health aspects of water programs should be encouraged to join the proposed International Corps of the Public Health Service. Eventually, consideration also should be given to the possibility of establishing a multiagency International Water Service Corps. Membership in the Corps would be made available to specialists in all water-related disciplines, including hydrologists, engineers, agricultural specialists, foresters, soils specialists, technical educators, economists, lawyers, administrators, meteorologists, etc. Participation in the Corps might provide a number of special benefits to U.S. Govern-

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ment water specialists, including opportunities for obtaining responsible assignments with a number of U.S. agencies; participating in training sessions, seminars, and professional societies related to international water activities; opportunities to take special assignments on a sabbatical basis; and provision of literature and information on current professional developments while serving in overseas stations.

Encouragement can be provided to experts outside of government, as well as within, in many ways that do not cost very much but will generate great long-term benefits in mobilizing the capability of the U.S. to cooperate in the international Water for Peace Program. These include participation in U.S. and International conferences and seminars held to exchange information with respect to special problems, the publication of articles in professional journals dealing with international water matters, the systematic debriefing of water experts upon their return from overseas assignments, the encouragement of water studies at international centers to be established in the U.S. under the proposed International Education Act, and provision for instruction in foreign languages that are necessary to facilitate a man's contribution to international and regional programs. Rosters of trained personnel available for overseas water service should be expanded and disseminated. Information about employment opportunities in Federal agencies, with international organizations, and with the proposed regional centers should be circulated on a regular basis. The important objective of all these programs is to foster an awareness of the professional opportunities that are available to water specialists from all disciplines to concentrate on, or to augment their professional careers by, studies and work in oversea water problems.

Education and Training Programs

More than 91,000 foreign citizens were on American college and university campuses during the 1965 academic year. Some 82,000 were students and 9,000 were scholars engaged in research or teaching. Of 82,000 students, about 6,000 were financially supported by U.S. Government funds, primarily through AID in connection with its technical assistance programs. The remainder draw their support from foreign governments, private foundations and other institutions, and their own personal resources. It is not possible from available reports to ascertain how many of the students are specializing in water-related subjects, but the number is probably less than 1,000.

In addition, a number of Federal agencies provide training experiences in water programs through hosting foreign observers, visitors and trainees. Over the last 15 years, more than 7,000 persons have benefited from a diverse range of activities, including 5- to 12-month assignments working alongside regular employees in the Office of the Chief Engineer of the Bureau of Reclamation in Denver, training in soil and water conservation practices with the Soil Conservation Service, training in laboratory detection procedures and water pollution control at the PHS Taft Sanitary Engineering Center, and inspection trips to the Tennessee Valley Authority and other government installations.

These visiting scholars, students, observers, and trainees are assisted with travel and scheduling arrangements and orientation sessions by a number of private groups and government agencies. The latter include AID, of course, and the Bureau of Educational and Cultural Affairs (CU) of the Department of State.

While these extensive programs for education and training of foreign nationals in the United States have on the whole been very successful, a number of steps can be taken to improve the effectiveness of their contribution to international progress in water resources development. Exchange programs for professors, government officials, and other water specialists, as well as exchange fellowship programs for graduate students, should be expanded in coordination with the International Hydrological Decade. The Water for Peace Office should provide assistance in identifying training needs in overseas programs and relating these needs to the availability of training opportunities in the United States, in coordinating assignments, and in strengthening U.S. educational and training programs. One concern has been that all too often individuals trained at considerable expense in the United States either decide to remain here to pursue their profession or, upon their return to their native country, enter into jobs other than that for which they were educated. While this tendency is understandable, efforts should be made to reduce this loss by enlisting commitments from sponsoring entities that individuals who come to the United States for special training in the water field will be guaranteed effective employment in government or other organizations upon their return home. Continuing efforts should also be made to reduce the period of "cultural shock" that confronts many foreign nationals coming here for the first time, which may seriously handicap the individual's ability to adjust to his new environment and to derive full benefit from the course work and other educational opportunities available.

Typically, foreign students are thrown into course work and training situations designed to train Ameri-

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can students to meet the problems and to fill the jobs that exist in the United States. Much of this training, however, is not applicable to the problems and jobs which the foreign student will face when he returns home. This difficulty can be overcome in several ways. One is to establish special programs aimed at the training of foreign nationals. Examples of this kind from The Netherlands are the International Course in Hydraulic Engineering and the International Course for Hydrologists, cosponsored by UNESCO, and two International Courses in Sanitary Engineering, offered in cooperation with the World Health Organization. These courses are held on the campus of Delft Technological University; the specially organized Netherlands Universities Foundation for International Cooperation (NUFFIC) handles the international aspects and financing. These courses draw candidates from all over the world and have contributed significantly to making Dutch and other European expertise available in a practical way to experts from many countries. Another mechanism is to enable supervising professors of graduate students in the United States to work out research projects for doctoral theses within the student's home country or region. Under such an arrangement the supervising professor should have the opportunity to return to the student's country on at least two occasions to advise him in the design and conduct of the research project.

Mobilizing Private Participation

The United States possesses a tremendous reservoir of private talent in the vast complex of water-related specialties which should be drawn upon to support the activities of the U.S. Government under the Water for Peace Program. A number of techniques are available to provide greater participation by experts from the scientific, academic and industrial domains and from the public at large. An advisory committee composed of outstanding experts in their fields should be established to work with the Water for Peace organization; the U.S. National Committee for the International Conference on Water for Peace might well provide a basis for this advisory group. A number of people-to-people programs are in existence, and encouragement should be given to including water development activities in their efforts. One such operation is the highly successful Partners-in-Alliance Program under which one-to-one relationships have been fostered between local groups in American States and individual countries or groups of states in Latin America.

Private participation should be enlisted in such Water for Peace activities as conferences, seminars, and publication exchanges, as well as in technical assistance programs. Under section 3 of the pending International Education Act of 1966, the Secretary of Health, Education, and Welfare would be empowered to promote the establishment of graduate centers in the United States, undertaking studies of international areas and problems. Arrangements should be made to include concentration on water development problems in the programs of these centers.

As discussed earlier in this chapter, a major effort in the Water for Peace Program will be the strengthening and establishment of regional institutions and programs in the water field. As these institutions develop, it will be necessary to encourage parallel groupings of academic, private, and Federal competency within the United States to provide mutual support for and a special relationship with the regional centers. This might be done through the formation of cooperative arrangements among neighboring complexes of university, industrial, and Federal institutions in this country. Specialization in the water problems of the region would be encouraged, and nationals from the region coming here for education and training might be funneled to these complexes.

D. International Conference on Water for Peace

The U.S. Government will sponsor an International Conference on Water for Peace in Washington, D.C., on May 23–31, 1967. This conference will be attended by representatives of governments including those of ministerial rank, observers from international and nongovernmental organizations, and individual experts. The purpose of the conference will be to identify problems, exchange knowledge, discuss goals, and consider action programs in the furtherance of a worldwide cooperative effort aimed at the solution of water problems. The conference will not itself, however, be a negotiating body to formulate recommendations or make decisions.

An international exposition will be held in conjunction with the conference. Both government and nongovernment organizations in the United States and abroad will be encouraged to prepare exhibits. A U.S. Government exhibit will be included and should be prepared by the best available experts from all interested departments and agencies. A U.S. National Committee to conduct the conference will be organized, consisting of government representatives and of private representatives from about 25 American orga-

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nizations, institutions and enterprises. The United States will provide preconference assistance, where appropriate, to interested nations in conducting studies and assembling information related to conference subjects. Plans are being made also, with the help of interested government agencies and private individuals and businesses, for a choice of pre- and post-conference tours in the United States for conference participants to observe a variety of water-related activities and developments.

It is apparent that the international conference will play an important role in fostering the worldwide objectives of the Water for Peace Program. The agenda will provide an opportunity for the discussion of a wide range of practical problems that stand in the way of water progress. Particular emphasis will be given to the requirements for planning, organizing, staffing, administering, and financing water development projects and programs. Parallel sessions will be offered to government ministers having responsibility for water programs, and to experts representing all water specialties.

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VII. RECOMMENDATIONS

Introduction

The following recommendations are advanced by the Interdepartmental Committee on Water for Peace in the belief that they are worthy of consideration to stimulate the rate of progress in water development throughout the world and to promote a more systematic framework in which the efforts of individual countries and international organizations can be coordinated to fulfill this end.

The recommendations take into account the programs the President has launched to combat hunger, ignorance and disease and the corresponding planned increases in U.S. aid to international agricultural, educational, and health programs. Although addressed to the subject of what the United States additionally might do, both through its own programs and through its representation and voice in international councils in urging other nations to make parallel and cooperative contributions, the recommendations are founded on the basic premise that nations and regions of the world which have water problems and desire to respond to them by promoting water development, must undertake this responsibility themselves. Through the international Water for Peace Program the world community can exchange knowledge and experience, offer encouragement, supply technology, and provide technical and financial assistance, but one nation or region cannot do the job for any other. This principle of self-help is fundamental to the program.

The recommendations are for both short- and long-term actions. Although they focus on water problems and ways to solve them, all such efforts should be planned within the broader framework of the overall economic and social development requirements of the respective country or region. The goal of giving the less developed countries increased ability to solve their own problems requires stress on more extensive planning; education and training at the subprofessional and professional levels; institution building; discovery of new ways to utilize local labor, local materials and equipment, and local sources of finance; and enhanced application of science and technology. A regional or subregional approach to many of these problems can be especially useful.

In the long run, progress in solving water problems wil be measured through new capital construction, ranging in size from the installation of simple sanitation facilities to the construction of large-scale river basin projects. Most of the financing inevitably must come from local and national sources. Supplementary capital assistance must also be provided from international and bilateral sources, at expanded levels; requirements for this financing will need to be under constant review and should be related to the ability of countries to use the assistance effectively.

The recommendations that follow are not mutually exclusive. Some overlap; all are complementary. For example, the program under the International Hydrological Decade supplements activities covered in four preceding sections on regional centers, education and training, research and information and data. This does not result in a duplication of activity, rather, the objectives of one recommendation will be advanced by the successful carrying out of other related recommendations.

Following each recommendation or group of recommendations are references to the pages in the main body of the report where the subject is discussed more fully.

1. *Water for Living*

a. *Goals.*—We recommend that the United States encourage countries and regions having water supply problems to establish realistic goals for their national efforts, as Latin America has done in the Charter of Punta del Este. For example, consideration might be given to establishing the goal that by 1980 the percentage of urban and rural populations in the developing countries served by piped drinking water will be increased at least by 50 percent.

b. *U.S. Bilateral Community Water Supply Development Program.*—(1) We recommend an increase in U.S. financial assistance to community water supply and sewerage projects in areas of critical need. This

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assistance should include provision for necessary institutional support to establish and operate water supply installations, including training programs and the enactment of national water legislation if necessary.

(2) We recommend that the United States sponsor and cooperate in studies into ways and means to sharply accelerate improvement in urban and rural water supplies throughout the developing world consistent with the establishment of an institutional base that will in the future provide adequate water supplies financed largely through local revenues.

c. *International Water Supply Effort.*—We recommend that the community water supply programs of the World Health Organization (WHO) and the Pan American Health Organization (PAHO) be strengthened and that all governments and other international organizations increase technical assistance and capital support for community water supply programs.

d. *Desalination.*—(1) We recommend that the United States offer to assist in the construction of—

(*a*) Small- and medium-scale desalination plants, including solar stills, in those areas where the need for additional drinking water is critical, where humanitarian purposes would be fulfilled, and where there is no obviously cheaper source;

(*b*) Desalination plants in areas where acute water shortages exist or occur unexpectedly or where economic development is retarded to the point of stagnation;

(*c*) Large-scale desalting plants, particularly when joined with the production of electrical energy, which can make a dramatic impact in the solution of specific water problems. Decisions to assist in capital arrangements for such large-scale plants will, of course, have to be preceded by careful assessment of individual projects as presented.

(2) We recommend that the United States continue to offer to provide all appropriate technical assistance to countries interested in developing desalting projects.

e. *Pollution Control.*—(1) We recommend that the Water for Peace Program be used as a foundation for a world effort at providing clean, health-preserving water. The U.S. contribution to this, which will depend heavily on the expanded Community Water Supply Development Program of AID, should be coordinated with those health activities which are to be carried out under the proposed International Health Act of 1966, and also with the health activities of other governments, the specialized agencies of the U.N., and other organizations as appropriate.

(2) We recommend that pollution problems both in developed and developing countries be discussed at the International Conference on Water for Peace.

2. *Water for Food*

a. *Goals.*—We recommend that the United States encourage countries needing more water and water management for increased food production to establish specific goals, at least over the next 10 years to support their plans for food production to feed their expected population. Goals should be set for the development of water resources through improved water uses, supplemental water supply, elimination of flood damage, improved water management, installation of needed drainage facilities, addition of new irrigation acreage, and fish production and processing.

b. *Expansion of AID Programs.*—It is recommended that AID's expanded activities in support of the President's Food for Freedom Program include assistance for the solution of agricultural water problems, including planning, training, development of irrigation and reclamation facilities, flood control and drainage improvements, which, together with that furnished by all other sources, will support the attainment of the planned levels of food production.

c. *Support to the Food and Agriculture Organization.*—We recommend that the United States urge the strengthening of the FAO, especially with respect to increased development and improved use of surface and ground water resources, and irrigation, drainage and flood control, for agriculture; improvement and management of upland watersheds; and greater production of fish for food, particularly fish farming in conjunction with agricultural land use, notably in rice-producing areas, and for conducting studies, inventories and the establishment of demonstration projects for promoting fishery production in coastal estuaries.

d. *Opportunities for Fish Production and Processing.*—Water development programs, where appropriate, should provide for protection of fishery resources and their development, including methods for harvesting, processing, distribution, and marketing in an efficient and economic manner. Emphasis should be placed on management for sustainable yield of fisheries resources and on development of fish protein concentrate from freshwater species.

e. *U.S.-Owned Local Currencies for Water Development.*—(1) We recommend that, within the context of country program priorities, a portion of U.S.-owned excess local currencies be offered for the creation of agricultural development banks (or be added to the resources of existing banks) for irrigation and other

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water conservation and development activities and for making loans to farmers for these purposes.

(2) We recommend that foreign currencies to be obtained under the Food for Freedom Program be used more extensively for the development of water projects.

(3) We recommend that a larger share of excess foreign currency funds available to the U.S. Government be used for research on water-related problems. Where congressional authorization is required, it should be sought. Any other limitations which might prevent the use of such funds for research on local water problems within developing countries should be removed.

f. *Special Demonstration Projects.*—We recommend that AID give special attention to large-scale projects for demonstration and training of nationals, consisting of coordinated development of water and land resources to be established in tributary watershed areas in selected countries or regions suffering a critical food shortage. In most instances these projects could be integrated with or become a part of river basin development projects.

3. *Water for International Cooperation—International Rivers*

We recommend that nations sharing international river basins as well as appropriate U.N. agencies be encouraged to give special attention to the cooperative development of international river systems, not only to realize the full economic values of their development but also because such effort is in itself a valuable encouragement to general international cooperation.

In support of this policy, we recommend:

(1) That the United States encourage the Secretary-General of the United Nations to pursue his suggestion of early 1966 to conduct a survey of the potential for development in international rivers, but along regional or subregional lines and on a selective basis with respect to specific river basin projects. Although financing of regional surveys would presumably be through the UNDP, the United States should be ready to make contributions to arrangements for such surveys.

(2) That the United States encourage with other interested nations and U.N. agencies to give priority to the development of at least one additional international river basin in each continent.

(3) That the United States encourage countries bordering on international rivers to join in creating appropriate international bodies to promote the cooperative development of the river systems.

(4) That the United States in calling the Water for Peace Conference invite the participants to report on studies of the development potentials of international river systems of particular interest to them.

4. *Regional Centers for Water Resources Development*

(1) We recommend that the United States offer to assist in the creation or strengthening of a number of regional or subregional centers for water resources development, where appropriate, under the leadership of regional and subregional international entities, particularly the United Nations regional economic commissions and the Organization of American States. The sponsoring organization and the participating countries of the region should in each case work out the location and functions of the center and its relations with other institutions.

(2) The sponsoring organization and the participating countries of the region should clearly establish their determination to provide long-term support for each center.

(3) The United States should be prepared, at least by the time of the international conference, to offer to contribute a substantial percentage of the annual cost for the first 5 years of nine new centers. The goal might be to establish or expand two centers in 1968, three in 1969, and four in 1970.

5. *Education and Training*

a. Regional Institutions for Professional Training.—We recommend the creation or enlargement of a number of regional or subregional institutions and programs for professional training sponsored by appropriate multinational groups or by national groups with appropriate multinational involvement. A major input also could come from participation by industrial and other private groups. The functions of these institutions, we suggest, would be to provide undergraduate and graduate education in water-related disciplines, either as separate institutions or as adjuncts to existing universities. The Water for Peace Program should be prepared to contribute to the support of these institutions, including arranging for the exchange of professors and scientists, as discussed below. These centers would complement, or, in appropriate cases, be combined with the Regional Centers for Water Resources Development proposed in recommendation 4 above.

b. Regional Technical and Vocational Training.—(1) We recommend that the United States, in cooperation with U.N. agencies and other countries, establish regional programs to train teams of instructors who can

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conduct vocational training in connection with water resources projects.

(2) We recommend that where special skills are required, special courses or training centers should be organized on a regional basis.

(3) We recommend an expansion of the U.S. program of sponsoring regional short-term institutes on a continuing basis outside of the United States for training technicians in water specialties.

(4) We recommend that private industry and other private groups be considered as a source of instruction, personnel, materials, equipment and financing in these programs.

c. Education and Training Programs in the United States.—We recommend that the U.S. Government assist universities, foundations, schools and Government agencies to improve their programs for the training of both foreign and U.S. nationals in curricula and practical field techniques essential to international water resources development. It would be desirable to have arrangements facilitating the return of advanced students in the United States to their own countries later to do thesis work.

d. *Exchange and Fellowships Programs.*—We recommend an expansion of exchange programs for professors, government officials, water specialists, and other experienced persons active in water matters. We also recommend an expansion of exchange fellowship programs for graduate students in all fields related to water resources development.

e. *Education Study.*—We recommend that the United States urge and support the initiation by an appropriate U.N. organization of a survey of available data concerning the facilities available and explicit needs for expanded education and training in water resources subjects.

f. *Peace Corps.*—We recommend that the Peace Corps give greater emphasis to training and direct assistance on water resources development activities.

g. Coordination With International Education Programs.—In his message on international education and health, the President made a number of proposals to strengthen U.S. position in international education programs. We recommend that as appropriate these programs include attention to education, training and study in the fields related to water resources development.

6. *Research and Surveys*

a. *Existing Research Programs.*—We recommend that on-going domestic research programs in the water field be encouraged and expanded, and that results and findings that could be of value in solving the world's water problems be made available to the world community on a regular basis.

b. *Research and Development on Specific Problems.*—We recommend that the Water for Peace Program give active support to research, including testing, directed to the solution of specific problems in water resources development that are particularly characteristic of the less developed countries. Funding could come in part from U.S.-owned local currency funds.

c. *Regional Centers for Tropical Research.*—We recommend that the United States contribute financial and other support to the establishment and operation of several regional or subregional research centers, where appropriate, to study water-related problems peculiar to tropical areas. This research function might be added to those already assigned to the proposed Regional Water Resources Development Centers. Participation by universities located in the regions should be enlisted by the centers.

d. *Cooperative Research and Studies.*—We recommend that broadly representative teams of U.S. experts be formed to engage in research and studies in cooperation with other countries on international and regional problems of water conservation and management of mutual interest.

e. *Resource Reconnaissance Surveys.*—We recommend that the developing countries participating in the international conference mutually establish a common goal of completing by 1975 compatible reconnaissance surveys of their water and related land resources. If possible, this would be desirable against a background of overall resource inventories; and demographic and economic surveys could also be useful. To this end, the United States should offer technical assistance, as requested, and employ all available and newly developed techniques of radar, modern photography, and remote-sensing equipment as appropriate.

f. *Use of Satellites.*—We recommend that the cooperation of the National Aeronautics and Space Administration (NASA) be enlisted in the Water for Peace Program to study the feasibility of making surveys of water and related resources on a world basis, using instrumented earth orbiting vehicles.

g. *Basic Data Networks.*—We recommend that the United States offer to assist with the planning, design, and establishment of new or enlarged basic-data networks and compilation systems, particularly in the developing countries.

h. *Resource Studies and Project Evaluation.*—We recommend that the United States provide increased support for planning studies of integrated resources

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development and in the application of project evaluation methods, and that the U.S. and international banking institutions be encouraged to expand their activities along these lines.

7. *Information, Data and Publications*

a. *Information and Data Retrieval.*—We endorse and support current U.S. efforts to establish facilities and advisory councils for coordinated water resources information retrieval and data storage and retrieval, and we recommend that the systems include categories relating to international water activities as well as domestic.

b. *Assistance to Regional Centers.*—We recommend that the United States provide assistance to the Regional Centers for Water Resources Development and to other regional groups in regard to the establishment of libraries, publications exchange, water information retrieval, and the development of interest profiles to take advantage of U.S. and other retrieval facilities.

c. *Publications Exchange.*—We recommend that studies of existing facilities and programs for international exchange of publications relating to water resources be made with a view to improving these programs and filling in the gaps; that limited funds be made available to finance publications exchanges; and that the subject of international publication exchanges be discussed at the international conference.

d. *Translations.*—We recommend that arrangements be made for the translations of pertinent technical reports, manuals, and textbooks into other languages where such materials are needed.

8. *International Hydrological Decade*

We recommend that the United States participate fully in the International Hydrological Decade, and we support the proposals of the U.S. National Committee for inclusion under the Water for Peace Program.

9. *United Nations Programs*

a. *Strengthened Water Program.*—We recommend that the United States reinforce and support the United Nations, the specialized agencies and the international development banks in accelerated and expanded programs for water resources development. We also recommend that the United States support increased allocation of funds for technical assistance and preinvestment surveys in the U.N. Development Program. The United States is planning to increase its pledge to the UNDP for 1967 by $5 million; and expects to continue increasing its contributions in future years, with the result that additional financing should be available for water development projects as well as other purposes.

b. *Intergovernmental Committee on Water Questions.*—It is recommended that the U.S. Government, in addition to its support of the U.N. Administrative Committee on Coordination, support the establishment of an intergovernmental committee on water questions under the Economic and Social Council in order to help fill the need for a higher level coordinating mechanism among the many elements of the United Nations that are concerned with water questions.

c. *Ground Water Surveys.*—We recommend that the United States encourage the U.N. to undertake a 5-year program of assembling, compiling and making available in published or other suitable form, information and data relating to the ground water resources in developing countries.

10. *Foreign Bilateral Programs*

We recommend that the United States representative inform the Development Assistance Committee (DAC) in Paris of the proposed Water for Peace Program, including the international conference, and urge increased support for water resources projects in the bilateral programs of the member nations.

11. *Water Law and Legal Institutions*

a. *Legal Aspects of International Rivers.*—The U.S. Government should encourage governmental and private organizations in the United States and abroad and international agencies to continue to study and make available the legal aspects of the use and development of water resources of international rivers and river basins. The United States should also encourage specific bilateral and regional arrangements, in each case of international river basin development, to establish agreed legal principles, including provisions for the settlement of disputes through permanent institutions selected for the particular development.

b. *Water Legislation.*—We recommend that assistance be provided by the United States, by regional centers and by other countries to each developing nation asking aid in establishing the codes and legal institutions necessary for the rapid and orderly development of its water resources. We also recommend that legal studies be included in the programs of U.S. international centers.

c. *U.N. Legal Experts.*—The United States should urge that U.N. development programs relating to wa-

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ter resources should provide legal experts to the countries being assisted. These experts should give advice and assistance on international and domestic water law problems and on the organization and functioning of international and domestic institutions needed for water resource development.

12. *Strengthening U.S. Capabilities to Support Overseas Water Development*

a. *Careers in International Water Service.*—We recommend that appropriate steps be taken to encourage U.S. experts in all water-related disciplines from both inside and outside of Government to concentrate on, or to augment their professional careers by, studies and work in overseas water problems.

b. *Expert Teams.*—We recommend an expansion in the capacity of the United States to send abroad qualified teams of water resources experts to provide various technical services to countries and regional entities requesting such help, particularly with regard to planning, administering, and financing water resource programs.

c. *Water for Peace Organization.*—We recommend the establishment within the U.S. Government of a Water for Peace Office, under interdepartmental guidance, to coordinate U.S. participation in overseas water resource efforts, to serve as a central point to stimulate interest in international water programs, and to ensure the effective discharge of U.S. commitments under the Water for Peace Program.

d. *Mobilizing Private Participation.*—The Water for Peace Program should promote the interest and cooperation in international water activities of individuals and of universities, private organizations, industry, and State governments, through such mechanisms as conferences and seminars, advisory committees, information exchanges, and group cooperation.

13. *The International Conference on Water for Peace*

The United States will sponsor an International Conference on Water for Peace in Washington, D.C., on May 23–31, 1967. This Conference should serve to identify problems, exchange knowledge, discuss goals, and consider cooperative action programs in furtherance of the worldwide objectives of the Water for Peace Program.

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Appendix I

The President's Water for Peace Address

(The President's Remarks to the Delegates to the First International Symposium on Water Desalination, Assembled in the East Room at the White House, October 7, 1965)

Distinguished Members of the Congress, Secretary Udall, distinguished signatories, symposium delegates, members of the press, ladies and gentlemen:

We are very pleased that you could join us here this afternoon. You represent more than 60 nations. You have come here from all parts of the world. You have come to search together for a common solution to a very common problem, and I think that no event could hold more promise for the peace and progress of man.

No international gathering ever met anywhere for a more important purpose. If science can unlock the door to an unlimited supply of pure and drinkable water, I think it will be an event in human history as significant as the harnessing of the atom.

Since the beginning of time, fresh water has always been one of humanity's most precious needs. For it many wars have been fought throughout history. Without it whole civilizations have vanished from the earth.

Now, we of this generation have an opportunity to put an end to all of that. Our generation realizes that we have the power. It is the power which you at this conference really represent. That power is the power of science. But if we are to use that power effectively we must use it together.

Nature is not impressed by the lines that we draw on these little maps. The clouds above us refuse to stop for border guards and so the rain falls upon the just and the unjust alike.

The earth's water belongs to all mankind. Together we just must find ways to make certain that every nation has it in full share and that there is really enough of it for all nations.

Now, that is the central purpose of the international symposium that you have been attending here in Washington. Since that is also the purpose of the agreement that we are about to sign, it seemed appropriate to me to ask you to come here and join us in this ceremony.

The United States of America and our good neighbor to the south, Mexico, share much in common, including the great areas which are very short of water. Together, with the help of the International Atomic Energy Agency, we are now going to explore a promising answer to a very difficult but a very mutual problem.

This agreement will help us discover whether nuclear power can be applied in a practical and economical way to convert sea water to generate electricity for the great arid region which joins our two countries.

President Diaz Ordaz and I are equally determined that every effort possible must be made to find new water for this thirsty part of this continent. We are going to look to the oceans and to the modern technology that you have been studying at your conference. We hope that that study will be a model for future cooperation among neighbors in all the regions of the world that are suffering from water shortage.

We have barely left the shore for the start of a very long journey. None know better than you how difficult is the task before us. But we cannot—we will not—we just must not delay it any longer.

Over various areas of the world today water is the key to man's prosperity or man's poverty—the key to his comfort or to his misery. Every 24 hours there are nearly 200,000 more people on this earth. A billion human beings also live on the ragged edge of starvation. Water is a prime necessity, for only if we have water can our growing populations ever be fed. Only water can give future generations a chance to escape wholesale misery and wholesale starvation.

My country, as you know, supports with enthusiasm a continuing Food for Peace Program. We support an Atoms for Peace Program. We are committed to

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harnessing the awesome power of nuclear energy for the betterment of humanity.

And today I want to announce the beginning of a Water for Peace Program. Under this new program we will join in a massive cooperative international effort to find solutions for man's water problems.

As I have already announced, the United States has already launched a new 5-year, $200 million program of research and development to lower the cost of desalting water. But the time has now come to move beyond research and development.

Therefore, I shall present to the next session—I repeat, next session—of the U.S. Congress a plan and a program with proposals and recommendations—realizing that the Executive makes proposals and you make disposals—for constructing practical prototype plants to make the fullest use of our technological discoveries. Those discoveries already promise plants that are capable of producing up to 10 million gallons of fresh water every day by 1968, and 100 million gallons a day by 1970.

But the need is worldwide. It is not limited to any one country—not even ours. And so should be our effort in trying to meet that need.

Therefore, today I call upon all the nations of the world to join us in the creation of an international fund to bring the fruits of science and technology to all the corners of a parched and thirsty world.

The United States is prepared to contribute its share of the resources needed for an international crash program to deal with world water resources. We ask other nations to join us in pursuit of a common objective.

That objective is: Water for all humanity.

In pursuit of that objective, the United States—in addition to efforts that I have just described—is prepared to build upon the achievements of this desalting conference by announcing now that we would convene within a year another great conference to deal with all the world's water problems; and by announcing now to increase our support for the scientists of more than 70 nations that are now working on water problems for the United Nations; and to announce now that we are willing to send our own best experts abroad, when requested, to establish a program of grants or fellowships to bring scientists from other lands to our own United States to engage in further study and additional research.

All this, I think, must be the beginning and not the end by any means of our efforts.

I earnestly believe that desalting is the greatest and is the most hopeful promise that we have for the future. I have believed it for a long time.

It was more than 10 years ago, as a U.S. Senator, that I warned—and I quote:

We have reached a point where very serious consideration must now be given to the pressure of individual, industrial, agricultural needs upon water resources of this Nation. We have already passed the time when we can afford to be complacent.

Well, the problem is far greater today than it was 10 years ago. There are more people in the world for one thing. They need a great deal more to eat. They need a great deal more to drink. They need more industry to clothe them, and more houses to house them. They can really never have any of these things without water.

And in the decade ahead we must accomplish more—much more—than in the decade past.

And I pledge to you that as far as I am concerned the United States is going to accomplish much more.

So the occasion which brings us together here this afternoon is testimony to the sincerity of our purpose.

The agreement that we are about to sign is just one more example of the joint efforts that are going forward every day under the Alliance for Progress Program. Under that program, last year we dispensed $159 million more than the combined allocation of the previous 2 years.

The 19 independent republics in Latin America and the United States have a partnership. We are all working to bring to all the peoples of the Western Hemisphere the fruits of modern science and modern technology.

So let us then extend that partnership. Let all of us—East and West—apply our science and our technology to this, the greatest of problems.

Let future generations remember us as those who freed man forever from his most ancient and dreaded enemies—drought and famine.

And now our efforts to free him from the enemies of drought and famine are to be extended to free him from ignorance by international educational programs; free him from disease by cooperative health adventures together.

And what a satisfaction it would be to everyone in this room if at some future date we can point back to this year when the United States of America was willing to put forth leadership to free humanity from the ancient enemies of mankind—poverty, illiteracy, ignorance, disease, thirst.

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Appendix II

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Appendix III

Three Case Histories of International Waterway Development

The Indus

The creation and execution of the Indus development plan is perhaps the greatest accomplishment in the last decade in the development of water resources for peace. In one remarkable exhibition of engineering imagination and international cooperation it solved a dangerously charged contest between India and Pakistan over water vitally needed for millions of their citizens and brought into being a joint effort with far-reaching possibilities for reducing the general antagonisms between the two countries.

The River Systems.—The Indus River system includes the Indus and five major tributaries. All rise in the Himalayas. The three eastern rivers—the Beas, Sutlej, and Ravi—flow through India and into Pakistan to join the Indus. The three western rivers—the Chenab, Jhelum, and Indus—flow out of Kashmir and Jammu before they enter Pakistan.

The Indus flows 1,800 miles from 22,000 feet up in Tibet to the Arabian Sea. The total system carries an annual average runoff of about 188-million acre-feet, about the same as the Columbia, two-thirds more than the Nile, three times the Tigris-Euphrates and over 10 times the Colorado.

Existing Irrigation.—The Indus Basin is some 200 miles wide and 800 miles long. About 50 million people now live in the basin, largely on land irrigated from the rivers. At the time of partition about 5 million acres were irrigated in India and 20 million in Pakistan. It is the largest irrigated area in the world with the largest system of irrigation works—nearly 5,900 miles of canals and tributaries in India and 29,000 in Pakistan.

Approximately 72 million acre-feet annually were being used for irrigation out of the 120 million acre-feet estimated as the potential average quantity of water available for irrigation. The area contains the largest block of contiguous arable land in the world.

The Disputes.—Disputes over the allocation of water from the Indus system began decades ago between the Sind and Punjab States of British India. When India was partitioned the boundary line went through the Punjab leaving the upper reaches of the Beas, Sutlej, and Ravi in India with their lower reaches in Pakistan. Before partition the Government of the Sind had already protested plans of the Punjab to divert more water from these rivers into canals in the Punjab. After partition, Pakistan continued the protest against India and the dispute was temporized by a series of standstill agreements but was not settled.

The Proposal.—In August 1951, Mr. David Lilienthal, former Chairman of the Tennessee Valley Authority suggested that it might be possible to reach a constructive solution of the problem if a plan could be worked out to use the total resources of the whole Indus system for the benefit of both countries. He suggested that the World Bank might sponsor the idea and arrange for a joint undertaking by the very able engineers available to both India and Pakistan.

After protracted negotiations by representatives of the Bank, particularly Sir William Iliff, and of the two governments, the Bank submitted an ingenious proposal consisting of five principal elements: First, that the waters of the three eastern rivers—the Beas, Sutlej, and Ravi—which flowed through India, be allocated to India and be allowed to flow out of the basin; and that the waters of the Chenab, Jhelum, and Indus, flowing in Pakistan, be allocated to Pakistan. In this way neither country would be dependent on the good will of the other for the continued flow of vital water. Moreover, each country could use its water freely according to its own plans without having to obtain the agreement of the other. Each country would arrange to build the works on its own territory.

Second, Pakistan would be compensated for the loss of the water of the eastern rivers for its eastern lands by the construction of a series of canals to take water from the western rivers to the eastern lands and others to replace water formerly entering Pakistan but allocated to India under the plan.

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Third, India in return for the additional waters from the eastern river would pay a part of the cost of the new replacement link canals.

Fourth, the Bank would advance loans for a substantial part of the cost of construction and would bring together a consortium of countries to provide the other money needed.

Fifth, India was not to diminish the supply of water to Pakistan during a 10-year transition period.

The Agreement

The Bank submitted its proposal to both governments in February 1954. It then undertook to arrange a plan of financing the $1 billion cost of the total project. Under the Bank's aegis a consortium was formed of Australia, Canada, the Federal Republic of Germany, New Zealand, the United Kingdom, and the United States. These nations with Pakistan and the Bank signed "The Indus Basin Development Fund Agreement" providing the equivalent of $894 million in commitments for the construction of the necessary works in Pakistan.

The Governments of India and Pakistan, joined by the Bank, signed an international water treaty, September 19, 1960, setting out the agreement between them for the development of the Indus Basin.

In the treaty, the Bank undertook responsibilities that were the key to the successful negotiation of the agreement and execution of the project: It is to receive and hold the contributions and pay them out under its normal procedures for work done. It is also to supervise the technical work of the project.

The arrangement also provides for an Indus Basin Commission with one Commissioner and necessary advisers from India and Pakistan. Detailed provisions are included for reference to disagreed matters to a neutral expert chosen by both parties and if that does not result in an acceptable settlement, for reference to an arbitration body to be established according to the terms of the agreement.

The U.S. Congress enacted legislation in the Mutual Security Act of 1960 (now sec. 303 of the Foreign Assistance Act) to enable the United States to participate in the financing of the Indus Basin development plan.

The Financing

In the original financing Australia, Canada, Germany, New Zealand, and the United Kingdom pledged the equivalent of $129.8 million in grant funds. The United States pledged $177 million in grants and $70 million in loans. In addition the United States pledged the equivalent of $235 million in rupees, earned primarily from the sale of surplus agricultural products under the Food for Peace Program—a significant example of the way in which the Food Program can support the Water Program which in turn will make it possible to grow more food in India and Pakistan. The IBRD also made a loan of $80 million.

In addition, in the Indus Water Treaty, India pledged an equivalent of $175 million to the Pakistan project as a compensation for the diversion of water to India.

To make possible the construction needed in India, the United States has promised to lend India $33 million and the Bank has promised to lend $23 million. India will provide almost $144 million equivalent in rupees for local currency costs.

In 1964 the consortium made additional commitments. Australia, Canada, Germany, New Zealand and the United Kingdom added $86.5 million in grants. The IBRD advanced another loan of $58.5 million. The United States raised its share by $118.6 million in grants and $51.2 million in loans. Pakistan will supply all rupee costs beyond the United States $235 million equivalent. Pakistan's costs are estimated at some $290 million in rupees.

The total commitment in foreign exchange to the works in Pakistan is now $774 million of which the United States share is $416.8 million or 53.8 percent. The total commitment in all currencies to the works is a little over $1 billion equivalent which the United States share is $651.8 million equivalent, or 62.8 percent.

Present Status

The Indus project is the largest earth moving task ever undertaken. It is now in its sixth year and is moving on or ahead of schedule despite the effects of hostilities between India and Pakistan in September 1965. Costs are running approximately at the estimates. The drawdown of U.S. commitments is estimated to about $31 million for fiscal year 1966 and about $33 million for fiscal year 1967.

Conclusions

The Indus waters dispute was one of the two major controversies between India and Pakistan—the other being the dispute over Kashmir—which disturbed their relations after partition. Each of these disputes tended to prevent the two countries from concentrating on their economic and social development, diminished the political stability of the area and created the danger of hostilities which might have had extensive consequences.

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The settlement of the Indus waters issue removed a major cause of friction between the two countries. It provided a constructive and valuable aid to their economic and social development and was a highly important advance in the general relations of the two countries.

Each of these consequences was a matter of great importance and value to further U.S. foreign policy objectives. Although the fighting broke out in the area in September 1965 as a result of heightened tensions over Kashmir, it seems most probable that hostilities could have occurred much earlier or could have been more severe and extended if it were not for the Indus waters agreement and the joint development program. It is significant that both sides refrained from injuring the water works in the area.

The Indus case suggests several lessons for the future: Little or no progress would have been made without the specific encouragement of the United States and the offer of very substantial U.S. financing. Although the United States could have acted as the intermediary and catalytic force, it was better that the IBRD, a respected international agency of which Pakistan and India are both members, should do so. The fundamental basis for success was the genuine desire of India and Pakistan to reach a mutually beneficial conclusion. This helped them triumph over many early disagreements. Imaginative and sound engineering by the Bank, producing more water for both parties, made agreement possible. The ability and willingness of the Bank to draw together the consortium and the willingness of its members to provide the necessary financing made the construction possible. The continued management of the Bank has maintained the confidence of all parties, guided the engineering work efficiently and helped keep cost within the estimate.

A significant factor of the arrangement is that work is to be open to bidders on an international basis. As a result construction work is now being carried out by contractors from the United States, Japan, Austria, West Germany, Italy, Switzerland, the United Kingdom, France, Denmark, and Australia as well as India and Pakistan.

In total, the Indus Basin Development Program has been one of the truly great political and engineering advancements of the decade and great credit is deserved by all who have participated in it. It furnishes a textbook example for guidance in the successful development of other international river basins.

The Mekong

So much attention has been focused for so long on the active hostilities in Vietnam that a peaceful enterprise of international scope in that region seems scarcely to belong in such a setting. In varying degree and location, the peoples of Indochina have lived with war for 20 years, and the scale of combat was never greater than it is today. It is all the more remarkable in these circumstances that an effort to develop the region's principal river for peaceful purposes could even exist, let alone progress. The fact that it has done both is a tribute to the vision and courage and sacrifices of those who have brought the project this far toward completion, and a reminder to cynics that it is possible for some peaceful endeavors to survive in the very cauldron of war.

The River System

The Mekong flows 2,600 miles, longer than the Mississippi, from the snows of Tibet to the China Sea. Of this, 1,500 miles is in the Lower Mekong below China. The Lower Mekong drains an area as large as New York and California together, with a population of some 30 million. The lower river has 34 principal tributaries. It is one of the largest rivers in the world, with an annual discharge of 400-million acre feet. The area through which it flows is so little developed that in all its 1,500 miles there is not a single bridge across the river.

Planning

The United States, through the Mutual Security Program, in 1956 stimulated the start of planning for Mekong development as a symbol and focal point for regional cooperation. The U.N. Economic Commission for Asia and the Far East (ECAFE) recommended in 1957 the establishment of a Committee of the riparian nations to look into the possibilities of developing the river.

The Mekong Committee

The Governments of Cambodia, Laos, the Republic of Viet-Nam, and Thailand thereupon jointly established the Committee for the Coordination of Investigations of the Lower Mekong Basin with one member from each nation and with "plenipotentiary authority * * * to promote, coordinate, supervise and control

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the planning and investigation of water resources development projects in the Lower Mekong Basin." The Committee may also solicit and administer funds. It is in effect an autonomous public international corporation. Significantly, the Committee established an executive agent to act for it.

The U.N. has confirmed its interest and support of the Mekong project through the Special Fund, ECAFE and 10 other U.N. cooperating agencies. In addition 21 nations, the Ford Foundation, the Asia Foundation and four major private industries are contributing money and technicians.

The Program

The program of the Mekong Committee is far broader in scope and variety as well as greater in size than the Indus or, indeed, any other international river basin development program. The Committee describes its objectives as follows:

The Mekong Project seeks the development of the water resources of the Lower Mekong Basin, including mainstream and tributaries, in respect of hydroelectric power development, irrigation, flood control, drainage, navigation improvement, watershed management, water supply and related developments for the benefit of all the people of the basin, without distinction as to nationality or politics. Work is broadly divided into the categories of: (a) preinvestment planning (including basic data collection, overall basin planning, planning individual mainstream and tributary projects, planning navigation improvements, and ancillary projects); (b) construction; (c) finance; and (d) management.

Thus far the Committee's attention has been directed primarily to preinvestment activities: basic data collection and the preparation of an overall basic plan. The Committee realizes explicitly that no single project should be undertaken without knowing how it will fit into the overall plan and that it will not prejudice a project needed to be undertaken later in the general scheme. The basic overall plan was stated in the 1957 ECAFE report, "Development of Water Resources of the Lower Mekong." The Committee decided in 1962 to prepare an amended and amplified plan in the light of accumulating data to be completed in 1967. To help in this work it is establishing an electronic computer facility in Bangkok to make a system analysis to help determine the optimum system, sizes and functions of dams, and reservoirs.

Three projects were given priority by the Committee as early as 1957: the Pa Mong, Sambor, and Tonle Sap.

The Pa Mong mainstream project, high up on the river on the Laos-Thailand border above Vientiane, would help control the flow of the entire river down to the sea. It would irrigate approximately a million hectares of land in northeast Thailand and Laos and could operate generators up to a million kilowatts. The United States agreed in 1961 to make the feasibility investigation for the Pa Mong project. The work is being done by the Bureau of Reclamation. The United States is also participating in a land classification survey in the area.

The Mekong Committee has taken a very broad approach to the problem of construction and operation of the Pa Mong project. It wants a U.N. agency to sponsor the work and to sell the power and irrigation water to Laos and Thailand and use the revenues to pay the costs.

The Sambor project on the mainstream some 100 miles above Phnom Phen would be a run-of-the-river dam that could turn 620,000 kilowatts of generating capacity with an annual output of 4.6 billion kilowatt hours and that would facilitate navigation up to Laos. The feasibility study for this project is being made by Japan. The Committee wishes to have Sambor constructed and operated by a U.N. agency as in the case of Pa Mong.

The Tonle Sap project would put a gated dam on the Tonle Sap River which runs from the Mekong near Phnom Phen to the Great Lake of Tonle Sap. During high water on the Mekong, the Tonle Sap runs toward the Lake, which acts as a reservoir. During low water on the Mekong, the water flows from the lake to the river. The proposed dam would regulate the flow, reducing the Mekong floods and maintaining a navigable depth on the Mekong during the dry season and providing other benefits. India has made the feasibility study and cost estimate for the dam and will combine the many other studies being made by other countries and agencies.

Tributary Projects

In addition to the studies for these three very large projects, the Committee has already undertaken investigations of 17 projects on tributaries of the Mekong and has started implementation on six dam and powerplant projects: The Nam Pong and Nam Pung projects in Thailand have been completed; the Prck Thrat in Cambodia, and the Lower se Done and Nam Dong projects in Laos are in the planning stage; and the Nam Ngum project in Laos has been approved. The Committee has also undertaken channel marking and dredging at several places on the river. It further

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plans to improve port and harbor facilities, build shipyards, and produce tugs and barges.

Social and Economic Planning

The Mekong Committee, with commendable farsightedness, has recognized that physical development without concurrent social and economic planning will be wasteful and even dangerous. It has therefore undertaken an organized program to examine the social and economic effects of the development program and the steps needed to keep them in proper phase.

The Committee has also extended its activities beyond water development to comprehensive regional agricultural planning, mineral development, experimental and demonstration farms, surveys of potential uses of power, a pulp and paper industry, health studies, and the legal aspects of international construction and operation of its mainstream projects.

Financing

The Mekong Committee seeks to finance its preinvestment work by grants and its construction projects by grants and loans. Thus far its total resources have amounted to more than $100 million. Of this, nearly one-third has come from the four member governments and two-thirds from the U.N., cooperating countries and other organizations. The comparatively heavy contribution of the local countries, considering their shortage of funds, indicates the sincerity of their determination to make the cooperative work succeed.

Future Plans

The Mekong Committee is now in a second 5-year plan ending in 1968. Under this plan it is trying to continue and extend the process of basic data collection; to prepare an amplified overall basin plan; to complete comprehensive feasibility reports on at least 12 tributary projects; to complete comprehensive feasibility reports on 3 mainstream projects; to progress in navigation improvement; and to move forward with a number of ancillary projects. The Committee also hopes during this period to obtain the financing necessary to construct at least eight of the tributary projects and bring the three great mainstream projects to the point that financial negotiations can be undertaken soon after. The Committee now estimates that it will need $23.4 million for staff work for its 5-year-program and $144 million equivalent for the construction it hopes to carry out in the 5-year period. It estimates that the three mainstreams projects will cost some $772 million equivalent.

U.S. Participation

The United States from 1956 to 1965 contributed $3.7 million in technical services and equipment for cooperative savings, data collection, and studies.

Its help has been directed primarily toward the hydrology and systems analysis for the whole Mekong development scheme and to two of the principal projects.

At the 17th session of ECAFE in New Delhi in 1961, the United States undertook to make a comprehensive feasibility study of the proposed very large Pa Mong project. Phase I of this survey has been completed and the second phase is being undertaken to determine the economic feasibility of the project. This will require 3 years and $9–12 million of AID funds.

In early 1965 the United States also undertook to pay approximately half the total costs—some $24.1 million—of constructing the Nam Ngum Dam and Powerplant in Laos, if plans for the project were adequately developed and if donors became available for the other half of the fund. The plans were developed and under U.N. leadership seven other nations have pledged the necessary funds. On March 16, 1966, President Johnson announced that the United States will provide the promised $12 million. The IBRD will administer the construction of the project.

Conclusion

The Mekong project is probably the largest, most varied international river development effort ever undertaken. The management of the program is well-organized with energetic participation of the riparian countries despite their differences of political and economic outlook, and the constant threat of envelopment in the hostilities which now beset South Vietnam. The cooperation of the U.N. agencies and the IBRD is excellent.

The offer of President Johnson in his Johns Hopkins University address of April 7, 1965 to ask the Congress to provide up to $1 billion for aid to accelerated social and economic development programs in southeast Asia could be enormous incentive to more rapid progress in executing the plans of the Mekong Committee. The Mekong Program already has a high priority in U.S. foreign aid plans. That priority is justified and should be maintained.

The Jordan

The causes for tension among the states in the Jordan Valley area of course lie far deeper than con-

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troversy over water rights. The fundamental cause is the determination of Israel to survive and thrive as a nation and the unwillingness of the neighboring Arab States to recognize its existence or contribute in any way to its progress. This fundamental reason is closely followed by the irritation arising from the plight of the nearly 1 million Arab refugees from Palestine. These refugees are principally resettled in Jordan but also in Egypt, Lebanon, and Syria, where they have been for some 16 years, fed and cared for by the U.N. Works and Rehabilitation Administration (UNWRA). But disputes over the waters of the Jordan River and its tributaries in this extremely arid region are a significant part of the total atmosphere of conflict in the area.

The River System

The Jordan System begins in the north with the Hasbani River, rising in Lebanon, the Baniyas River, rising in Syria, and the very short Dan rising in Israel and running into the Baniyas. These join the Jordan and flow into the north of Lake Tiberius (The sea of Galilee). (The Litani River, rising in Lebanon and flowing into the Mediterranean could be connected with the system by an interchange to the Hasbani.) The drop from the headwaters to Lake Tiberius is very swift, about 1,000 feet in 9 miles.

Below the lake, the Yarmuk enters the river from Jordan. The Wadi-al-Zarqa also enters the Jordan before the river ends in the Dead Sea.

The entire flow of the Jordan System is about 3 percent of the Tennessee River, but it is of grave importance to the 2.5 million people of Israel, the million people of Jordan and the half-million or more refugees living in Jordan.

Efforts to make use of the Jordan for power generation and irrigation date back to as early as the era of British control of Palestine in 1916. Little came of these efforts, which were all but submerged under the stormy events surrounding the birth of the modern state of Israel. By 1953 the bitterness between Israel and the contiguous Arab States had become so deep that the United States became concerned with the danger to peace that they posed. In response to this challenge to peace, the idea grew in the U.S. Government that by making major efforts to bring the nations of the area together in a plan to develop the Jordan System for their common benefit, it might be possible to reduce the tensions arising from conflicting claims to the limited supply of water, improve the situation of the refugees and materially reduce the irritations over them. Beyond these immediate benefits, the United States also hoped that by helping the nations of the region unite in an effort to provide enough water for all—or at least much more for all than would otherwise be the case—it might be possible to soften the basic antagonisms between Israel and the Arab States and lay a foundation for the growth of generally peaceful relations.

The Johnston Mission

With these hopeful objectives in mind, President Eisenhower appointed Mr. Eric Johnston as his Special Ambassador to work with Israel and the Arab countries to try to arrive at a single development plan acceptable to both sides.

To aid and encourage these nations to join in a mutually beneficial development program, the U.S. Government offered to help pay its cost. This offer ultimately rose to two-thirds of the estimated total cost of $200 million.

It is not important now to review the details of Ambassador Johnston's work, which extended nearly 3 years, or the details of the attitudes and actions of the Israeli and Arab Governments. Although his proposals failed to win acceptance by the governments concerned, they did bring both Israel and the Arab States to agree that a regional approach with a master plan was desirable and that both sides should share the water.

Indeed, both sides were moved to develop plans of their own. Although these plans differed materially in the allocation of water, they contained many of the same fundamental ideas for development. At least the concept of cooperative action had been grasped by the contending beneficiaries, even though its application might be long delayed.

Since the Johnston Mission

Since 1955, Israel has proceeded to build the National Water Conduit from the north of Lake Tiberius 100 miles southwest through almost the total length of the country to the Negeb where it was intended to use the water for irrigation of this near-desert area to settle large numbers of additional Jewish immigrants. This ultimate objective has been delayed because water has been more sorely needed in existing population centers along the conduit and because it has now begun to appear that scarce and valuable water may be used with far greater benefit for increased industrial development than for irrigation for agriculture.

The Arab Governments have charged the withdrawal of water from the upper end of Lake Tiberius to be taken by the conduit outside the Jordan Valley is

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an infringement of their rights and constitutes a threat to the peace and security of the Middle East.

The Arab Governments on their side have laid plans to proceed with the development of Jordan System waters available to them. Jordan is constructing the East Ghor Canal with U.S. aid to use Yarmuk River water to irrigate land in Jordan.

Further irrigation will require a dam on the Yarmuk. Jordan and Syria reached an agreement in 1953 for the joint use of the Yarmuk. Jordan is now planning the construction of a dam at Mukhaibah with Arab funds to provide power and irrigation water. A possible later development will be a dam at the Maqarin site. U.S. contributions to financing will rest on the assurance that Israel will receive part of the Yarmuk River's water as proposed by the unified plan. International Bank financing will depend on Israel's agreement to the project—an unlikely prospect at present.

The Arab States are also considering plans to divert water from the Hasbani and the Baniyas before they flow into Israel. Lebanon would take Hasbani waters by tunnel to the Litani-Jordan and Syria would take Baniyas water to the Yarmuk by canal, preventing its flow into Lake Tiberius. Israel has made plain, however, that such action to the detriment of Israel will be regarded as an act of aggression and that Israel will retaliate. The Arab States take this declaration seriously. And several short artillery attacks on the Arab work on the Hasbani have apparently deterred efforts to construct diversion works. But Israel's actions have also contributed to revival of Arab unity and a determination to rebuild Arab military strength.

Thus far, the river development undertaken by both sides have fitted within the framework of the unified plan offered by Ambassador Johnston. The United States has made it a condition of its aid to Israel for Jordan water projects that Israel stay within the Johnston distribution formula.

Although the United States did not succeed in the great objectives for which the Johnston mission was considered, the results have been worth many times the effort. Despite the deep feelings over water, there have not been serious hostilities over it. Both sides recognize the advantages of joint development—even if they have not been willing to agree to a plan. Thus far, the development by each of the two sides has been kept within the allocations of the unified plan.

Future Possibilities

Now a significant new factor has entered the equation: The possibility of actually creating additional useable water by recently developed desalting processes, conventional or nuclear power distillation plants or reverse osmosis. By desalting sea water, the total amount of useable water available in the area can be increased and thus the total amounts that could be made available for both sides could be increased.

Moreover, by proper locations of a desalting plant or plants the possibility that one side could divert Jordan system water to the injury of the other side can be decreased or removed.

Israel has already proposed the construction of a plant to desalt sea water and provide from 80 to 160 million gallons of fresh water per day and substantial amounts of electric power. The United States has agreed to supply technical advice to decide on the feasibility of such a plant and the best method to fuel it.

Egypt has announced its intentions to build a nuclear desalting plant.

Whether the fundamental antagonisms that make Israel and the Arab States unwilling to agree to a joint plan can now be overcome may be doubtful. These antagonisms are now probably greater than in 1955. But at least part of the increased tensions comes from use of Jordan system water—and plans for future use. The plans of both sides for future development are such that if they are carried out there will be a real danger of military action.

It is all the more important, therefore, that a renewed effort be made to settle the water problem. It is of critical importance to the economic progress of both sides, to the welfare of the Arab refugees and to the future peace of the area.

The course such a new effort should take is necessarily a matter for special and detailed consideration. It may be, however, that three elements could be helpful: The good offices of the International Bank which has succeeded so well in resolving the Indus dispute and bringing about a creative solution, the availability of a new fund in the Bank, which could help finance a desalting plant or plants to provide additional water in the area, and a renewal of the offer of U.S. financial assistance to a joint development program which could help provide permanent homes and livelihoods for the refugees and contribute to the growth of peaceful relations in the area.

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INTERDEPARTMENTAL COMMITTEE ON WATER FOR PEACE

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